National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas 77058

October 1999

Hardware Requirements Document (HRD) for the Human Research Facility Refrigerated Centrifuge

DRAFT COPY

LS-71078-1

PROJECT DOCUMENT APPROVAL SHEET

DOCUMENT NUMBER	DATE	NO. OF PAGES
LS-71074		

TITLE:

Hardware Requirements Document (HRD)
for the
Human Research Facility
Refrigerated Centrifuge

APPROVED:	NT3/GFE Assurance Branch
APPROVED:	EA5/A. Rodriguez Technical Manager

DATE	PREPARED BY	CHANGE APPROVALS	CHANGE NUMBER

Report Number	LS-71078-1	Date

Hardware Requirements Document (HRD)
for the
Human Research Facility
Refrigerated Centrifuge

Prepared by: ______________________________ ____________
S. Brandt — Date
Subtask Order Manager

Approved: ______________________________ ____________
J. McDonald — Date
Hardware Development Manager

Approved: ______________________________ ____________
D. Kilbourn — Date
Manager, Safety and Product Assurance

Approved: ______________________________ ____________
S. Bhaskaran — Date
Manager, Systems Integration and Development

Prepared by:

Lockheed Martin Space Mission Systems and Services
Houston, Texas
for
National Aeronautics and Space Administration
Johnson Space Center

REVISION/CHANGE APPROVALS

Date	Revision Letter	Change Number	Prepared by	Approved by:		
				Unit Manager	SR&QA Manager	Projects Manager

DOCUMENT NUMBER LS-71078-1	**DOCUMENT CHANGE/ REVISION LOG**	PAGE 1 OF 1

CHANGE/ REVISION	DATE	DESCRIPTION OF CHANGE	PAGES AFFECTED
BASIC			

Altered pages must be typed and distributed for insertion.

JSC FORM 278 (REV APR 81) NASA-JSC

CONTENTS

CONTENTS (Cont'd)

CONTENTS (Cont'd)

CONTENTS (Cont'd)

CONTENTS (Cont'd)

CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

°C	Degrees Celsius
°F	Degrees Fahrenheit
µsec	microseconds
A	amperes
AC	Alternating Current
ADP	Acceptance Data Package
APM	Attached Pressurized Module
AVT	Acceptance Vibration Test
CAM	Centrifuge Accommodation Module
CCB	Configuration Control Board
CFU	Colony Forming Unit
CIL	Critical Items List
cm	centimeters
COTS	Commercial-off-the-Shelf
CR	Change Request
dB	decibels
dBA	Acoustic Decibel Level
DC	Direct Current
DCN	Drawing Change Notice
DR	Discrepancy Report
DRD	Data Requirements Document
EEE	Electrical, Electronic, and Electromechanical
EMI	Electromagnetic Interference
EPCE	Electric Power Consuming Equipment
ESD	Electrostatic Discharge
EUE	Experiment Unique Equipment
EXPRESS	Expedite Processing of Experiments to Space Station
FC	foot candle
FMEA	Failure Modes and Effects Analysis
FRD	Functional Requirements Document
ft	feet
g	gravity
GCAR	Government Certification Approval Request
GFCI	Ground Fault Circuit Interrupter
GHz	gigahertz
GIDEP	Government and Industry Data Exchange Program
grms	gravity, root mean square

ACRONYMS AND ABBREVIATIONS (Cont'd)

HRD	Hardware Requirements Document
HRF	Human Research Facility
Hz	Hertz
ID	Identification
IMS	Inventory Management System
in	inch
ISIS	International Subrack Interface Standard
ISPR	International Standard Payload Rack
ISS	International Space Station
IVA	Intravehicular Activity
JEM	Japanese Experiment Module
JSC	Johnson Space Center
kg	kilograms
kHz	kilohertz
kPa	kilopascals
lbf	pounds force
m	meters
MHz	megahertz
mil	thousandths of an inch
min	minutes
ml	milliliters
mm	millimeters
mm Hg	millimeters of mercury
MPLM	Mini-Pressurized Logistics Module
msec	milliseconds
MSFC	Marshall Space Flight Center
µsec	microseconds
N	newtons
N_2	nitrogen
NASA	National Aeronautics and Space Administration
NIH	National Institute of Health
NSTS	National Space Transportation System
NTSC	
O_2	oxygen
oct	octave
ORU	Orbital Replacement Unit

Pa	pascal
para.	paragraph
PDA	Pre-delivery Acceptance
PDR	Preliminary Design Review
PFE	Portable Fire Equipment
PIA	Pre-installation Acceptance
PRD	Program Requirements Document
psi	pounds per square inch
psia	pounds per square inch absolute
PU	Panel Unit
PVP	Payload Verification Plan
QEPM&L	Qualified Electrical, Electronic, Electromechanical Parts, Manufacturers, and Laboratories
QVT	Qualification Vibration Test
rad	rads
RC	Refrigerated Centrifuge
rms	root mean square
RPM	revolutions per minute
sec	seconds
SEE	Single Event Effect
SIR	Standard Interface Rack
SOW	Statement of Work
SPL	Sound Pressure Level
SRD	Software Requirements Document
TBD	To Be Determined
TBR	To Be Resolved
TM	Technical Memorandum
TPS	Task Performance Sheet
TRR	Test Readiness Review
UOP	Utility Outlet Panel
USL	U.S. Laboratory Module
V	volts
VCDP	Verification Compliance Data Package
VC-S	Visibly Clean-Sensitive
Vdc	Volts, direct current
Vrns	volts, root mean square

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this Hardware Requirements Document (HRD) is to describe and delineate the methods by which the National Aeronautics and Space Administration's (NASA) Lyndon B. Johnson Space Center (JSC) will design, develop, test, and certify the refrigerated centrifuge for the International Space Station (ISS) Human Research Facility (HRF).

1.2 SCOPE

The requirements established herein are applicable only to the refrigerated centrifuge. This hardware requirements document identifies unique, general construction, and environmental design requirements in Sections 3, 4, and 5 respectively. Section 6 identifies the certification approach. For HRF, certification is defined as the combination of acceptance and qualification. Sections 7 and 8 describe the acceptance and qualification approach and tests respectively. Detailed facility and functional test plans will be written separately for specific certification tests as they are required. These detailed test plans (not necessarily formalized documents) will include sections on specific test procedures, instrumentation requirements, and test support fixture configuration.

2.0 APPLICABLE DOCUMENTS

The following specifications, standards, and publications are considered applicable to this HRD because they are each specifically called out in individual requirements in this HRD. No document/specification will appear in this section without being referenced in a HRD requirement section. Revision letters shall accompany the document call-outs so that work authorization documents can be written from this HRD. If the HRF Master List of Documents is revised to reflect an updated document revision, the impact to this and all other HRF documentation will be accessed via a Change Request (CR) processed through the Configuration Control Board (CCB).

(NOTE: If no revision is indicated, the basic release is implied).

2.1 SPECIFICATIONS

Document Name	Rev.	Document Title
MIL-S-19500	J	General Specifications for Semiconductor Devices
MIL-S-7742	B Change 1	General Specification for Screw Threads, Standard, Optimum Selected Series
MIL-S-8879	C Change 1	General Specification for Screw Threads, Controlled Radius Root With Increased Minor Diameter
MS33540	J Change 1	General Practices for Safety Wiring and Cotter Pinning
NHB 5300.4	(1F)	Electrical, Electronic, and Electromechanical (EEE) Parts Management and Control Requirements for NASA Space Flight Programs
NSTS 1700.7 ISS Addendum	B	Safety Policy and Requirements for Payloads Using the International Space Station
SE-M-0096	A	General Specification for Materials and Processes, Requirements for JSC Controlled Payloads
SN-C-0005	C	National Space Transportation System Contamination Control Requirements
SSP 30237	B	Space Station Electromagnetic Emission and Susceptibility Requirements
SSP 30245	B	Space Station Electrical Bonding Requirements
SSP 30312	F	Electrical, Electronic, and Electromechanical (EEE) and Mechanical Parts Management and Implementation Plan for Space Station Program
SSP 30695	A	Acceptance Data Package Requirements Specification

2.2 STANDARDS

Document Name	Rev.	Document Title
FED-STD-595	B	Federal Standard 595B Colors Used in Government Procurement
ISIS-02	Draft C 5/98	International Subrack Interface Standard (ISIS) Drawer Specification
JSC 23642	C	JSC Fastener Integrity Testing Program
JSCM 8500		JSCM Engineering Drawing Practices
MIL-STD-810	E	Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests
MIL-STD-975	M	NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts List
MIL-STD-1686	C	Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment
NASA-STD-6001	Basic 2/29	Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion
SSP 50005	B Change 1	International Space Station Flight Crew Integration Standard
SSP 50008	B	International Space Station Interior Color Scheme

2.3 PUBLICATIONS

Document Name	Rev.	Document Title
ARC/BRP-40006	A Change 1	SSBRP Laboratory Support Equipment
JPD 5335.1	A	Johnson Space Center Quality Manual
KHB 1700.7	B	Space Shuttle Payload Ground Safety Handbook
LS-71000		Program Requirements Document for the Human Research Facility
LS-71001	A	Functional Requirements Document for the Human Research Facility
LS-71002		System Safety Program Plan for the Human Research Facility
LS-71004	Draft 11/97	System Integration and Verification Plan for the Human Research Facility
LS-71005		Configuration Management Plan for the Human Research Facility

Document Name	Rev.	Document Title
LS-71010		Fracture Control Plan for the Human Research Facility
LS-71011		Acoustic Noise Control and Analysis Plan for the Human Research Facility Payloads and Racks
LS-71020	Change 1	Software Development Plan for the Human Research Facility
LS-71026	Draft 1/96	HRF Reliability Plan
LS-71030	Draft 10/97	Quality Assurance Plan for the Human Research Facility
MIL-A-8625	F	Anodic Coatings for Aluminum and Aluminum Alloys
NASA TM 102179	6/91	Technical Memorandum – Selection of Wires and Circuit Protective Devices for STS Orbiter Vehicle Payload Electrical Circuits
NSTS/ISS 13830	C Change 1	Payload Safety Review and Data Submittal Requirements for Payloads Using the: - Space Shuttle - International Space Station
NSTS/ISS 18798	B Change 3	Interpretations for NSTS/ISS Payload Safety Requirements
NSTS-21000-IDD-MDK	B Change 2	Middeck Interface Definition Document
SED QSI 3.7	E	Preparation of Verification Compliance Data Package
SP-T-0023	B	Specification Environmental Acceptance Testing
SSP 30223	G	Problem Reporting and Corrective Action for the Space Station Program
SSP 30233	E	Space Station Requirements for Materials and Processes
SSP 30242	D Change 2	Space Station Cable/Wire Design and Control Requirements for Electromagnetic Compatibility
SSP 30243	E Change 3	Space Station Requirements for Electromagnetic Compatibility
SSP 30423	F	Space Station Approved Electrical, Electronic, and Electromechanical (EEE) Parts List
SSP 30512	C	Space Station Ionizing Radiation Design Environment
SSP 41002	G	International Standard Payload Rack to NASA/ESA/NASDA Modules Interface Control Document

Document Name	Rev.	Document Title
SSP 52005	B	Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures
SSP 57000	C	Pressurized Payloads Interface Requirements Document
SSQ-25002	A Change 6	Supplemental List of Qualified Electrical, Electronic, Electromechanical (EEE) Parts, Manufacturers, and Laboratories (QEPM&L).

2.4 SELECTION OF SPECIFICATIONS AND STANDARDS

Specifications and standards necessary for design and development shall be selected in the following order of preference, except as otherwise specified in this document. The exact issue shown is to be used, unless otherwise specified in this document.

In the event of conflict, the order of precedence shall be:

1. LS-71000, Program Requirements Document (PRD) for the Human Research Facility
2. JSC Drawing number(s) as referenced in this document
3. NASA specifications and standards
4. Manned spacecraft criteria and standards
5. Federal specifications and standards
6. Military specifications and standards
7. Other governmental specifications and standards
8. Specifications released by nationally recognized associations, committees, and technical societies

3.0 UNIQUE DESIGN REQUIREMENTS

This hardware requirements section contains a general hardware system description (for reference) and the hardware system performance, load, physical (e.g., weight, envelope, etc.), interface, and software design requirements. The Certification Matrix found in Appendix B specifies the method of compliance for each of the following requirements.

3.1 REFRIGERATED CENTRIFUGE

3.1.1 Description

A centrifuge is a mechanical device used to separate substances of different densities. Centrifuges may be used to quickly separate substances that would normally separate slowly under the influence of gravity. The refrigerated centrifuge is intended to provide a system of separation of biological samples based on differing sample densities in a controlled temperature environment. The centrifuge will be capable of separating blood into its components and separating saliva from saturated dental cotton rolls. The refrigerated centrifuge will be a Commercial-Off-the-Shelf (COTS) centrifuge, repackaged into an 8 Panel Unit (PU) drawer (see Figure 3-1 for the Functional Block Diagram). The drawer will utilize two connectors from the rear of the rack. (Reference Figure 3-2 for the Interface Block Diagram). The refrigerated centrifuge will provide performance data as well as some hardware health data. The data will be transmitted to the Data Acquisition System in Rack 2.

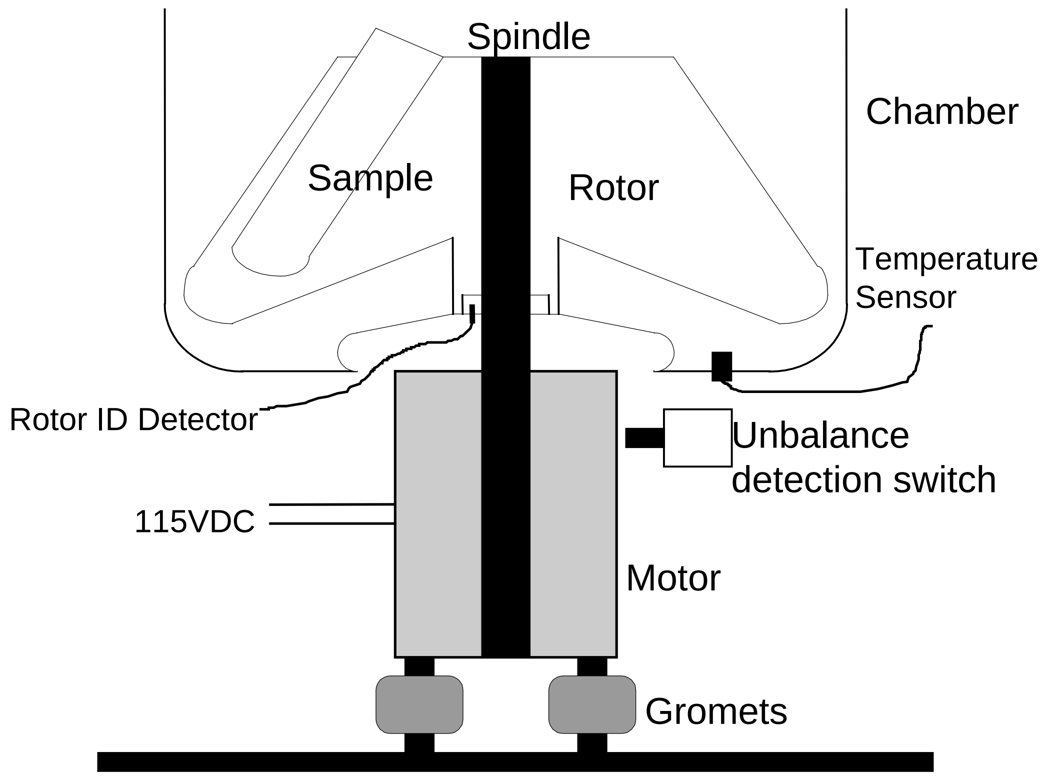
The refrigerated centrifuge consists of two main components: 1) the refrigeration system and 2) the rotor assembly.

3.1.1.1 Refrigeration System

The refrigeration method utilized by the centrifuge is vapor compression cycle. Vapor compression systems consist of four components: a compressor, a condenser, an evaporator, and an expansion device (see Figure 3.1-1).

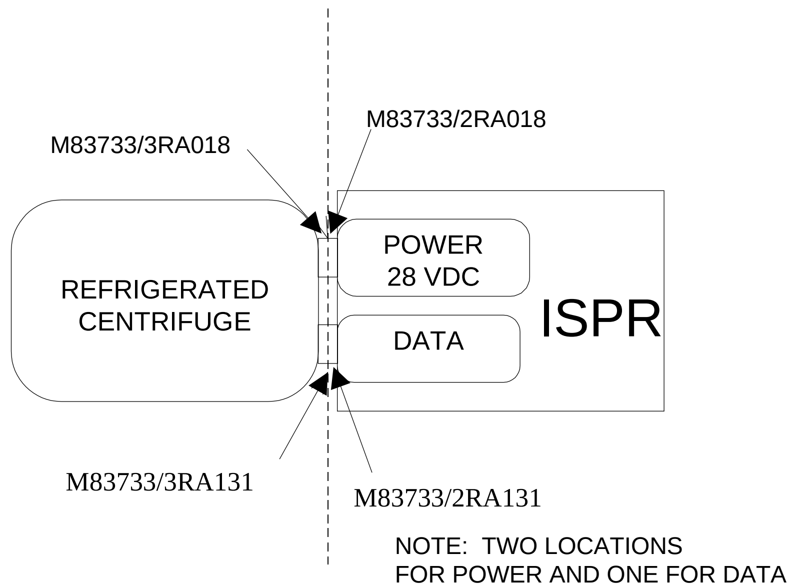
The compressor takes low pressure, low temperature refrigerant gas and compresses it to high pressure, high temperature gas. The compressor accomplishes this in a manner similar to that of an automobile engine. Reciprocating pistons intake vapor at low pressure and compress the vapor before sending it to the discharge line. The cool, low pressure gas entering the compressor is referred to as suction gas. The high pressure, high temperature gas exiting the compressor is called discharge gas. The existing compressor relies on oil sumping at the bottom of the compressor to lubricate the gears and therefore is gravity dependent.

From the compressor, the hot, high pressure gas travels through the discharge line into the condenser. The condenser is the part of the system where the heat is rejected by, as the name implies, condensation. An everyday example of condensation is a container of cold water left outside on a hot summer afternoon. Since the surface of the container is cooler than the air which surrounds it, water begins to leave the air, and form drops on the container. As the water condenses from the air onto the surface of the container, it loses energy and therefore cools. In the vapor compression system, as the hot gas travels through the condenser, it is cooled by air passing over it. As the hot gas refrigerant cools, drops of liquid refrigerant form within the coil.



CENTRIFUGATION - FUNCTIONAL BLOCK DIAGRAM

Figure 3-1. Functional Block Diagram



RC ELECTRICAL INTERFACE DIAGRAM - RACK MOUNTED (8PU DRAWER)

Figure 3-2. Interface Block Diagram

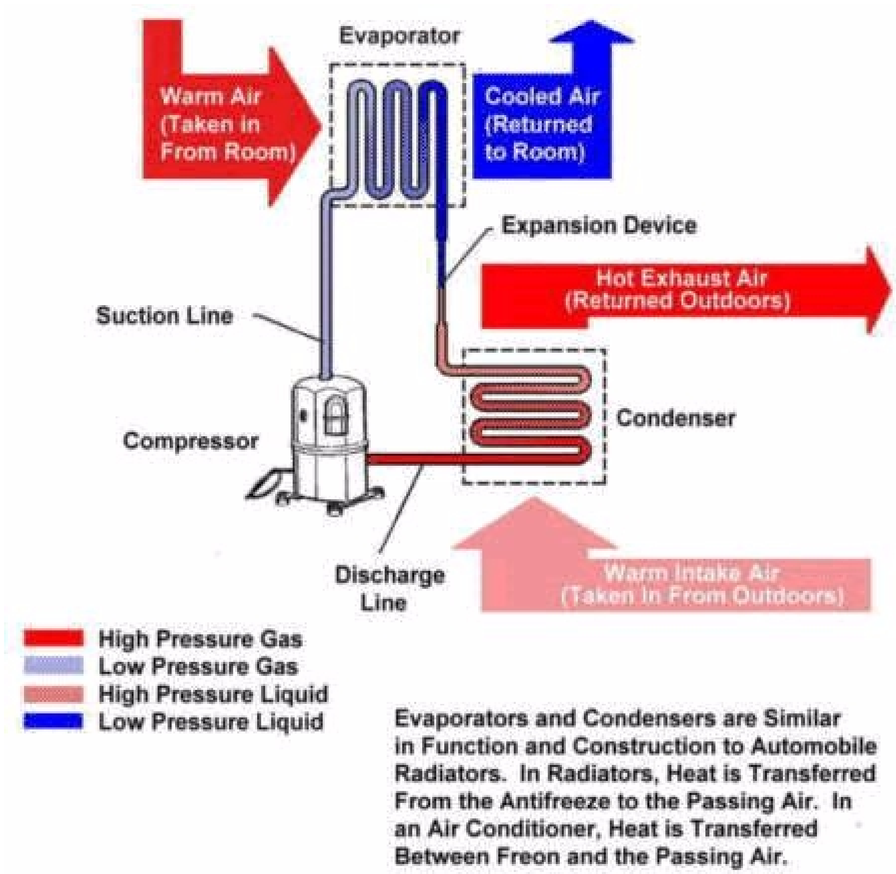


Figure 3.1-1. Vapor Compression Cycle

Eventually, when the gas reaches the end of the condenser, it has condensed completely, that is, only liquid refrigerant is present. Just like the water condensing onto the surface of the container of cool water, the refrigerant has lost some of its energy and cooled. In order for the condenser to function correctly, the fluid passing through the fins of the condenser (usually, air) must be cooler than the working fluid of the system (freon).

The purpose of the expansion device in a vapor compression refrigeration cycle is to control the flow of refrigerant to the evaporator. As the refrigerant leaves the condenser, it has cooled and condensed to liquid, but is still under high pressure. In order for the liquid to absorb the necessary heat in the evaporator, its pressure must be reduced, which is accomplished within the expansion device. The refrigerated centrifuge uses a capillary tube to accomplish this. Capillary tubes are lengths of tubing with a small inside diameter, which regulate fluid control through careful control of length and diameter. When compared with other expansion devices, the use of capillary tubes allows for less refrigerant in the system, as well as the elimination of the need for additional components such as sight glasses or receivers.

The evaporator is the component of the cycle, which actually absorbs the heat from the conditioned space. The evaporator is similar in construction to the condenser, but its function is opposite. Thinking back to the container of water, which was left outside on a hot summer afternoon, imagine that the container sits in the sun and has warmed. As the water continues to warm, it evaporates, leaves the container, and becomes vapor. This is the same process that happens to the refrigerant inside the evaporator. As the fluid leaves the expansion device, it is a cool liquid. As it passes through the evaporator, it picks up heat from the room and evaporates into a gaseous form. This evaporation is what enables the refrigerant to absorb the heat energy from the room.

As the refrigerant leaves the evaporator, it is returned to the cooled, low pressure state and is sent back to the compressor to begin the cycle again. Under normal circumstances the refrigerant will not wear out; it will be reused again and again, changing its physical form, but not its chemical composition.

The refrigerant is the fluid present in the vapor compression refrigeration cycle used to absorb heat in the evaporator and release heat in the condenser. The refrigerant is used again and again, cycle after cycle, but does not wear out under normal operating circumstances. The refrigerated centrifuge uses R404a as its working fluid. R404a is environmentally friendly and has been given a toxicity of 0 and is safe to use.

3.1.1.2 Rotor Assembly

There are three rotors that are being provided as part of the refrigerated centrifuge system. Each rotor has adapters that allow the user to size tube holder diameter down to the vial size diameter. The table below is a description of each rotor and specific adapters.

Rotor Max Capacity	50 ml	10 ml	2.2 ml
Adapters	12 and 7 ml	5 ml	1.5 and .5 ml
Max speed	6000 RPM	5000 RPM	18,000 RPM

The HRF Refrigerated Centrifuge (RC) will be a COTS unit that will be modified to meet flight requirements. Modifications currently identified are:

1. Modify or replace the compressor with a non gravity dependent compressor.
2. Modify power and/or compressor motor to make it compatible with Direct Current (DC) power.
3. Conformal coat the Printed Circuit Boards.
4. Develop a mounting mechanism to reconfigure to fit in an 8 PU drawer.
5. Repackage internal components.
6. Add vibration isolation to reduce micro-gravity disturbances to the rack.
7. Add labels.

3.1.2 Deliverables

The following is a list of deliverables as stated in the Task Order MHSCE5HHX.

		Quantity		
Part Number	Description	Class I	Class II	Class III
MIKRO 22R	COTS			1
MIKRO 22R	Evaluation Unit (partial prototype)			1
SEG46117400	Prototype			1
SEG46117400	Qualification Unit (later used as trainer)		1	
SEG46117400	Flight Unit	2		
SEG46117400	Rotors/Adapters	TBD		

3.1.3 Operations

During launch and landing, the refrigerated centrifuge shall be rack mounted in an 8 PU active drawer. During on-orbit operations, the refrigerated centrifuge shall be rack mounted in an HRF Rack 8 PU active drawer.

The refrigerated centrifuge will be used to separate biological samples such as blood and saliva. The front panel of the 8 PU drawer will open to expose the centrifuge rotor. The crew member will select a rotor as identified in the experiment protocol procedures. The rotor is removed and replaced with the use of an Allen wrench that is provided as part of the centrifuge system. The Station-provided tool kit will also include an Allen wrench, which could be used for this purpose. The samples will be loaded, and the door will be closed. The controls will be set for the appropriate time, temperature, rotor speed, and ramp up and down speeds. At the end of the centrifugation, the samples will be removed and placed elsewhere according to the specific experiment protocol. The crew will need to wipe down the chamber with a dry wipe to remove any condensation. They will also need to clean the chamber down with a disinfectant wipe. The door design includes an electro-mechanical latch, which is activated any time the rotor is spinning.

3.1.4 Performance Requirements

This HRD uses LS-71001, “Functional Requirements Document (FRD) for the Human Research Facility” to, in part, derive the HRD performance requirements. Section I of the applicability matrix found in Appendix A is a one-to-one mapping of the hardware item functional requirements (functional and technical) to the performance requirements within this HRD (Section 3.1.2). In cases where the FRD requirement has been allocated into a design requirement, that specific HRD requirement paragraph number is indicated. The annotation “DELETION” shall indicate that a functional requirement has not been implemented into the design, and the traceability matrix comment field will indicate the reason. The annotation “ADDITION” shall indicate a functional requirement that is now in the design, but was not in the FRD.

3.1.4.1 Centrifugation

The refrigerated centrifuge shall provide a system for separation of biological samples based on differing sample densities.

3.1.4.2 Timed Centrifugation

A. The centrifuge shall be capable of running from 1 to 30 minutes.
B. The run time shall be selectable in one minute increments.
C. There shall be a hold feature to allow for indefinite run times.

3.1.4.3 Programmable Force

A. The refrigerated centrifuge shall provide selectable force over a minimum range of 1000 to 5000 RPM .
B. The force shall be selectable in increments of 100 RPM, ±10.

3.1.4.4 Sample Sizes

A. The centrifuge shall accommodate sample sizes from .5 to 50 ml.
B. The centrifuge shall accommodate a maximum of 6 of the 50 ml vials at a time.

3.1.4.5 Programmable Protocols

The refrigerated centrifuge shall provide programmable centrifugation protocols that may be overridden if necessary.

3.1.4.6 Visual Alert

The refrigerated centrifuge shall provide a visual alert when centrifuge protocol has ended.

3.1.4.7 Emergency Stop

The refrigerated centrifuge shall provide an emergency stop capability.

3.1.4.8 Unbalanced Conditions

The refrigerated centrifuge shall provide the capability to detect unbalanced conditions during centrifugation and automatically shut down the centrifuge.

3.1.4.9 Refrigeration

A. The refrigerated centrifuge shall provide refrigeration of the rotor chamber to a minimum of +4 °C ± 2 °C -4°C.

B. The temperature set points shall be selectable in increments of 2 °C.

3.1.4.10 Controlled Acceleration/Deceleration

The refrigerated centrifuge shall be capable of manually controlled (or equivalent) rotor acceleration and deceleration.

3.1.4.11 Displays

A. The temperature of the rotor chamber shall be displayed continuously while in use.

B. The rotor speed shall be displayed continuously while in use.

3.1.4.12 Data Interface

The RC will interface with the host command and data system located on the rack.

3.1.5 <u>Physical Requirements</u>

3.1.5.1 Maximum Dimensional Envelope

The RC drawer shall not exceed the maximum dimensions specified in Figure 3.1.5.1-1. (PRD 6.2.1.2.3)

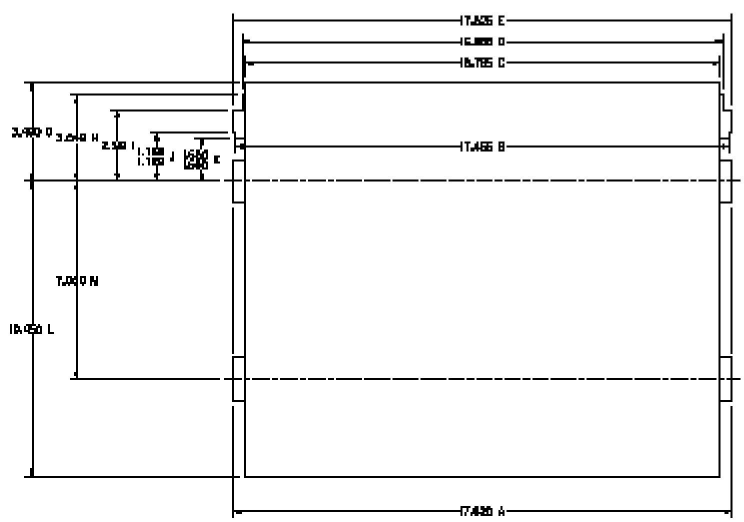


Figure 3.1.5.1-1. Maximum 8 PU Drawer Envelope (Front View)

3.1.5.2 Dimensional Tolerances

The RC dimensional tolerances shall be in accordance with Table 3.1.5.2-1. (PRD 6.2.1.2.2)

TABLE 3.1.5.2-1. DIMENSIONAL TOLERANCES

English Dimension	Tolerance
X.XX	± 0.030
X.XXX	± 0.010
X°	± 1°

3.1.5.3 Front Panel Permanent Protrusions

A. The RC front panel permanent protrusions shall be limited to the area between Standard Interface Rack (SIR) drawer handles. (PRD 6.2.1.1.5A)

B. The RC front panel permanent protrusions shall not extend beyond SIR drawer handles. (PRD 6.2.1.1.5B)

3.1.5.4 Center-of-Gravity Constraints

The refrigerated centrifuge shall meet the 8 PU center of gravity constraints specified in Table 3.1.5.3-2, HRF SIR Drawer Center-of-Gravity Constraints. (PRD 6.2.1.2.4)

3.1.5.5 Mass (Weight)

The weight (mass) of the refrigerated centrifuge and all drawer components shall not exceed 64 pounds per set of slide guides, or a total of 128 pounds (58.06 kg).

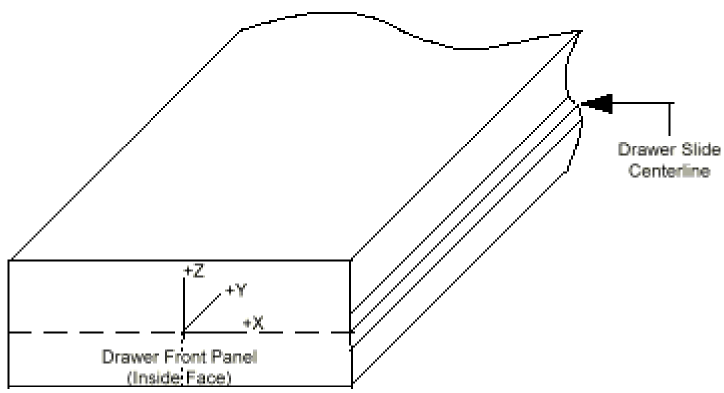
3.1.6 Software Design Requirements

TBD

TABLE 3.1.5.3-2. HRF SIR DRAWER CENTER OF GRAVITY CONSTRAINTS

DRAWER CONFIGURATION	X (in) MIN.	X (in) MAX.	Y (in) MIN.	Y (in) MAX.	Z (in) MIN.	Z (in) MAX.
Single Slide Drawer (4 PU)	-1.75	+1.75	+7.99	+12.00	-0.63	+0.87
Double Slide Drawer (8PU)	-2.20	+2.20	+10.24	+14.00	+1.675	+3.975
Triple Slide Drawer (12PU)	-1.50	+1.50	+9.74	+13.00	+6.37	+8.87

NOTE: Center of gravity envelope is measured from the drawer coordinate system as defined below. The geometric center for "Z" axis is measured from the centerline of the bottom-most rail toward the top of the drawer. Total maximum integrated mass (including drawer, contents and slides) on any one set of slides is limited to 64 pounds. Multiple-slide drawers are to evenly distribute loading between the sets of slides.



4.0 INTERFACE REQUIREMENTS

4.1 STRUCTURAL MECHANICAL INTERFACE REQUIREMENTS

Structural requirements are provided for HRF rack SIR drawer and seat track interfaces. Requirements for building a SIR drawer enclosure are not contained in this section, but can be found in the International Subrack Interface Standard (ISIS) Drawer Specification, document number SSP 50321.

4.1.1 Safety Critical Structures

The RC shall be designed in accordance with the requirements specified in SSP 52005. (PRD 6.2.1.1.1)

4.1.2 Dynamic Pressure

A. The RC shall maintain positive margins of safety for Mini-Pressurized Logistics Module (MPLM) depress rates of 890 Pa/second (7.75 psi/minute) and repress rates of 800 Pa/second (6.96 psi/minute). (PRD 6.2.1.1.6A)

B. The RC shall maintain positive margins of safety for the on-orbit depress/repress rates identified in SSP 41002 paragraph 3.1.7.2.1. (PRD 6.2.1.1.6B)

4.1.3 First Modal Frequency

The RC shall have a first modal frequency of not less than 35 Hz for launch and landing, based on rigidly mounting the instrument at the rack to SIR drawer instrument interface. (PRD 6.2.1.1.2)

4.1.4 Standard Interface Rack Drawer Structural/ Mechanical Interfaces

The RC drawer shall interface to the HRF rack through slide guide assemblies consisting of slide guides, striker assemblies, and connector bars in accordance with Section 6.2.1.2.1 of LS-71000. (PRD 6.2.1.2.1)

4.1.5 Microgravity

4.1.5.1 Quasi-Steady Requirements

To Be Determined (TBD) (PRD 6.2.1.1.7A)

4.1.5.2 Vibratory Requirements

TBD (PRD 6.2.1.1.7B)

4.1.5.3 Transient Requirements

TBD (PRD 6.2.1.1.7)

4.2 ELECTRICAL INTERFACE REQUIREMENTS

Electrical requirements in this section are defined for instrument interfaces to the HRF rack 28 volt power outputs at HRF rack connector bars and rack connector panel. For the purposes of this section, compatibility means to remain safe and to provide operational functions within the range of accuracy specified for the instrument. (PRD 6.2.2)

4.2.1 Human Research Facility Rack Power Output Connectors

4.2.1.1 Standard Interface Rack Drawer Power Connectors

The refrigerated centrifuge shall receive electrical power from two HRF rack connector bar interfaces and be compatible with blind mate receptacle part number M83733/2RA018.

4.2.2 Voltage Characteristics

4.2.2.1 Steady-State Operating Voltage Envelope

The RC shall be compatible with steady-state voltages within the range of +25.5 volts to + 29.5 volts. (PRD 6.2.2.2.1)

4.2.2.2 Transient Operating Voltage Envelope

The RC shall be compatible with transient voltages within the range of +23.5 volts to + 30.5 volts for 60 ms. (PRD 6.2.2.2)

4.2.2.3 Ripple Voltage/Noise Characteristics

A. The RC shall be compatible with a 1 volt peak to peak ripple in supply voltages within the ranges specified for steady-state and transient voltage envelopes. (PRD 6.2.2.2.3A)

B. The RC shall be compatible with the ripple voltage spectrum shown in Figure 4.2.2.3-1. (PRD 6.2.2.2.3B)

4.2.3 Maximum Current Limit

HRF RC shall be compatible with the maximum current provided for the selected current rating (20A) shown in Figure 4.2.3-1. (PRD 6.2.2.3-1)

4.2.4 Reverse Current

HRF rack dependent instrument reverse current shall not exceed the following values at each 28 V power interface: (PRD 6.2.2.4)

1. 600A pulse with a duration less than 10 µsec.
2. 450A peak with a duration less than 1 msec.
3. 2A continuous.

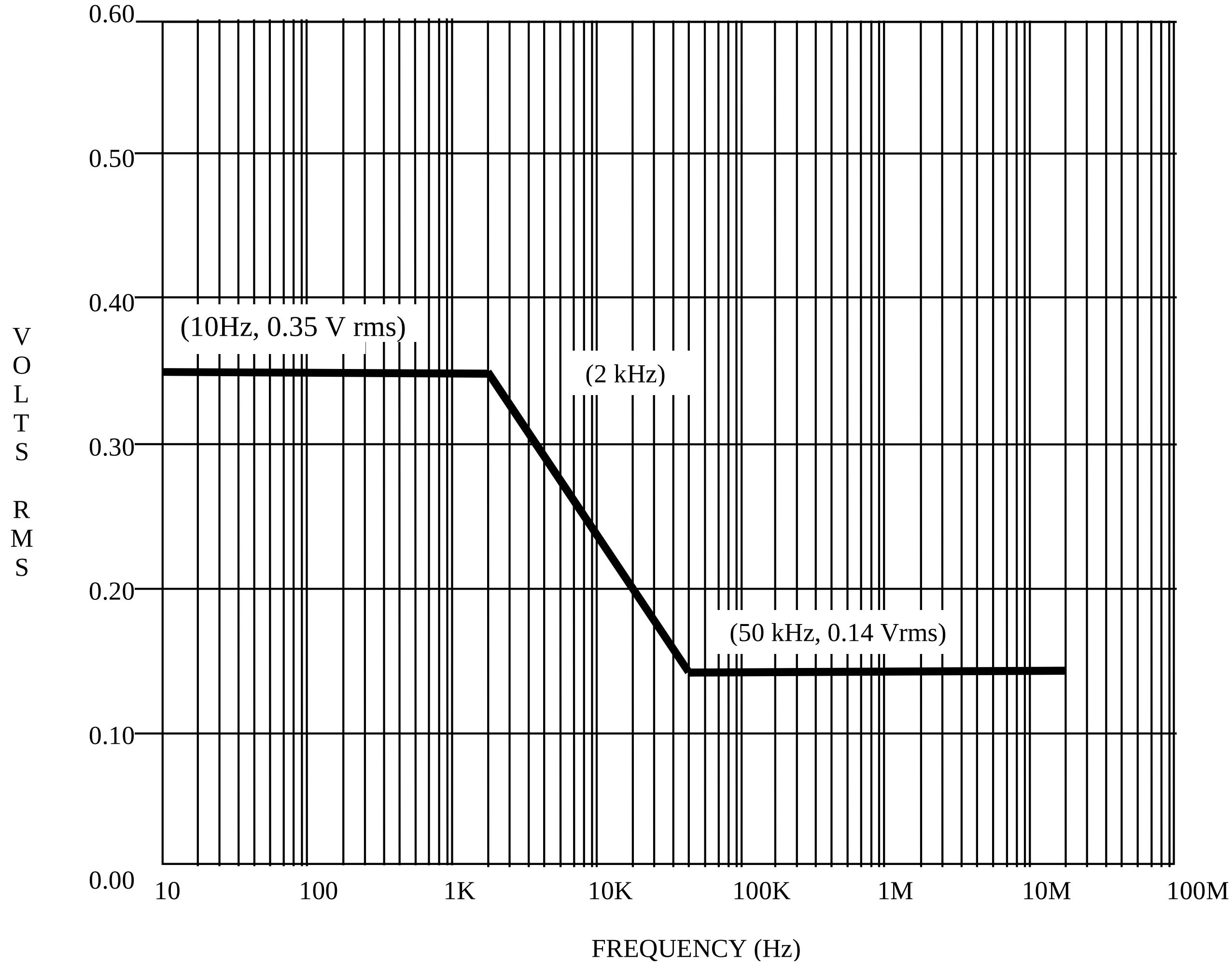
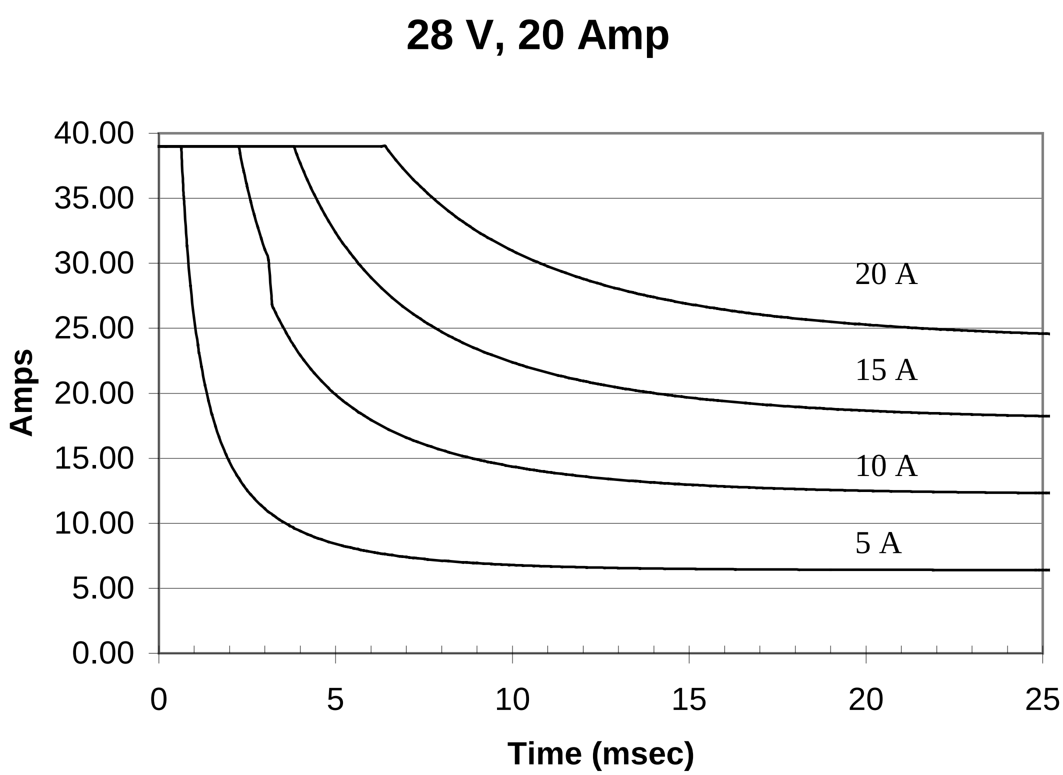


Figure 4.2.2.3-1. HRF Rack Power Output Ripple Voltage Spectrum



NOTES:

1) Current limit region shown above is defined for a capacitor load charge. In a direct short condition the actual trip time is 1/2 of the values shown.
2) For a progressive short in which the change in current has a slow rise time, an absolute maximum current limit of 2.5 times the normal current limit is provided. The time to trip for this condition is dictated by the I^2 x t trip limit.
3) Final current limit is obtained with in 100 µsecs. and the initial current limit is a maximum of 2 times the final.
4) The current limit is 39.0A +/-20%.
5) The trip values for the long-duration portion of the trip curves are a nominal 120% of range.

Figure 4.2.3-1. HRF Rack Power Output Trip Curves

4.2.5 Reverse Energy

HRF rack dependent instrument reverse energy shall not exceed 4 Joules at HRF rack 28 V power interfaces. (PRD 6.2.2.5)

4.2.6 Capacitive Loads

HRF rack dependent instrument capacitive loads shall not exceed 50 microFarad per Ampere of rated output current at SIR drawer and rack connector panel power interfaces. (PRD 6.2.2.6)

4.2.7 Electrical Power Consumer Constraints

4.2.7.1 Wire Derating

A. Circuit element derating criteria for instruments connected to HRF rack 28 volt power interfaces shall be per NASA Technical Memo (TM) 102179 as interpreted by NSTS 18798, TA-92-038. (PRD 6.2.2.7.1A)

B. Circuit element derating shall be based on the maximum trip current for a 20 A Solid State Power Controller as specified in Figure 4.2.3-1. (PRD 6.2.2.7.1B)

4.2.7.2 Exclusive Power Feeds

Cabling shall not occur between Interface C Utility Outlet Panel (UOP) connected Electric Power Consuming Equipment (EPCE) with Interface B; and/or Interface B connected EPCE with Interface C. (PRD 6.2.2.7.2)

4.2.7.3 Loss of Power

Payloads shall fail safe in the event of a total or partial loss of power regardless of the availability of auxiliary power in accordance with NSTS 1700.7B, ISS Addendum. (PRD 6.2.2.7.3)

4.2.8 Electromagnetic Compatibility

The RC shall meet the payload provider applicable requirements of SSP 30243, paragraphs 3.1, 3.5, and 3.6.2. (PRD 6.2.2.8)

4.2.8.1 Electrical Grounding

HRF RC shall meet all requirements specified in Section 3 of SSP 30240. (PRD 6.2.2.8.1)

4.2.8.2 Electrical Bonding

Electrical bonding of the RC shall be in accordance with SSP 30245 and NSTS 1700.7B, ISS Addendum sections 213 and 220. (PRD 6.2.2.8.2)

4.2.8.3 Cable/Wire Design and Control Requirements

The RC shall meet all cable and wire design requirements of SSP 30242. (PRD 6.2.2.8.3)

4.2.8.4 Electromagnetic Interference

The RC shall meet all Electromagnetic Interference (EMI) requirements of SSP 30237. (PRD 6.2.2.8.4)

NOTE: The alternative use of RS03 stated below applies to radiated susceptibility requirements only.

Alternately, the HRF RC may choose to accept a minimal increase of EMI risk with a somewhat less stringent Electric Field Radiated Susceptibility (RS03) requirement on equipment considered to be non-safety critical to the vehicle and crew. The tailored RS03 requirement, shown below, will hereafter be denoted RS03PL.

Frequency	RS03PL Limit (V/m)
14 kHz - 400 MHz 5	5
400 MHz - 450 MHz	30
450 MHz - 1 GHz	5
1 GHz - 5 GHz	25
5 GHz - 6 GHz	60
6 GHz - 10 GHz	20
13.7 GHz - 15.2 GHz	25

COMMENTS: The less stringent RS03PL limit was developed to envelope the electric fields generated by ISS transmitters and ground-based radars tasked to perform space surveillance and tracking. Ground-based radars that are not tasked to track the ISS, and search radars that could momentarily sweep over the ISS are not enveloped by the relaxed RS03PL. For most scientific payloads, the minimal increase of EMI risk for the reduced limits is acceptable. The RS03PL limit does not account for module electric field shielding effectiveness that could theoretically reduce the limits even more. Although shielding effectiveness exists, it is highly dependent on the EPCE location within the module with respect to ISS windows.

4.2.9 Electrostatic Discharge (ESD)

Unpowered, the RC and components shall not be damaged by ESD equal to or less than 4,000 V to the case or any pin on external connectors. HRF RC components that may be damaged by ESD between 4,000 and 15,000 V shall have a label affixed to the case in a location clearly visible in the installed position. Labeling of HRF RC susceptible to ESD up to 15,000 V shall be in accordance with MIL-STD-1686. These voltages are the result of charges that may be accumulated and discharged from ground personnel or crewmembers during equipment installation or removal. (PRD 6.2.2.9)

4.2.10 Alternating Current (AC) Magnetic Fields

The generated AC magnetic fields, measured at a distance of 7 centimeters (cm) from the generating equipment, shall not exceed 140 dB above 1 picotesla for frequencies ranging from 30 Hz to 2 kHz, then falling 40 dB per decade to 50 kHz. (PRD 6.2.2.10)

4.2.11 Direct Current Magnetic Fields

The generated DC magnetic fields shall not exceed 170 dB picotesla at a distance of 7 cm from the generating equipment. This applies to electromagnetic and permanent magnetic devices. (PRD 6.2.2.11)

4.2.12 Corona

Not Applicable.

4.2.13 Electromagnetic Interference Susceptibility for Safety-Critical Circuits

RC safety-critical circuits, as defined in SSP 30243, shall meet the margins defined in SSP 30243, paragraph 3.2.3. (PRD 6.2.2.13)

4.2.14 Safety Requirements

The RC shall meet the electrical safety requirements as defined in NSTS 1700.7B ISS Addendum. (PRD 6.2.2.14)

4.2.14.1 Electrical Safety

4.2.14.1.1 Mating/Demating of Powered Connectors

The RC shall comply with the requirements for mating/demating of powered connectors specified in NSTS 18798, MA2-97-093. (PRD 6.2.2.14.1.1)

4.2.14.1.2 Safety-Critical Circuits Redundancy

The RC shall meet the safety-critical circuits redundancy requirements defined in NSTS 18798, ET12-90-115. (PRD 6.2.2.14.1.2)

4.2.15 Power Switches/Controls

A. Switches/controls performing on/off power functions for the RC shall open (dead-face) all supply circuit conductors, except the power return and the equipment grounding conductor while in the power-off position. (PRD 6.2.2.15A)
B. Power-off markings and/or indications shall be used only if all parts, with the exception of overcurrent devices and associated EMI filters, are disconnected from the supply circuit. (PRD 6.2.2.15B)
C. Standby, charging, or other descriptive nomenclature shall be used to indicate that the supply circuit is not completely disconnected for this power condition. (PRD 6.2.2.15C)

4.2.16 Ground Fault Circuit Interrupters GFCI)/Portable Equipment Direct Current Sourcing Voltage

Not Applicable.

NOTE: The definitions of hazard requirements are specified in NSTS 1700.7B, ISS Addendum, paragraph 200.

4.2.17 Portable Equipment/Power Cords

Not Applicable.

4.3 COMMAND AND DATA HANDLING INTERFACE REQUIREMENTS

4.3.1 Human Research Facility Rack Data Connectors

4.3.1.1 Standard Interface Rack Drawer Data Connectors

The RC shall connect to blind mate connector part number M83733/2RA131.

4.3.2 TIA/EIA-422 Interfaces

The RC shall meet TIA/EIA-422 standards. **[PRD 6.2.3.3]**

4.3.3 HRF Software Requirements

A. File pathnames required for proper execution of the software shall be read from a configuration file rather than "hard coded" in the software. **[PRD 6.2.3.7A]**

B. The RC shall execute in the environment described in the host system IDD. (Workstation, Laptop, Common Software) **[PRD 6.2.3.7B]**

C. The RC software executable shall generate consistent results given the same initialization data. **[PRD 6.2.3.7C]**

D. User interface software shall comply with the Display and Graphics Commonality Standards (DGCS) (http://139.169.159.8/idags/dgcs.html) and the International Space Station Operations United States Payload Operations Data File Payload Display Implementation Plan. **[PRD 6.2.3.7D]**

E. Real-time data shall be formatted in accordance with the Life Sciences Data System (LSDS) Format. **[PRD 6.2.3.7E]**

4.3.4 ISS C&DH Services Through HRF Common Software Interface

Rack dependent instruments obtaining HRF rack and Payload MDM services (e.g. ancillary data requests, file transfer, report health and status, etc.) through the HRF Common Software shall request services in accordance with LS-71062-8, "Interface Definition Document for the Human Research Facility Common Software."
[PRD 6.2.3.8]

4.4 PAYLOAD NTSC VIDEO INTERFACE REQUIREMENTS

Not Applicable. The refrigerated centrifuge does not require video interface

4.5 THERMAL CONTROL INTERFACE

4.5.1 Human Research Facility Rack Heat Exchangers

The refrigerated centrifuge shall utilize two air to fluid heat exchangers provided by the rack, one at each 4 PU SIR drawer location. (modified PRD 6.2.5.2)

4.4.1.1 Heat Exchanger Interface Maximum Heat Load

The refrigerated centrifuge shall limit heat load into the heat exchanger to less than or equal to TBD Watts. (PRD 6.2.5.2.1)

4.5.1.2 Standard Interface Rack Drawer Cooling Fans

A. Fan Hardware

The RC shall use a HRF common fan, part number SEG46116060-701, defined in NASA/JSC drawing SEG 46116060. This drawing identifies the fan, mounting information, leadwire length, connector and pinout requirements. (PRD 6.2.5.2.2A)

B. Fan Location

The fan shall be located on the inside of the payload drawer in the rear right hand side (as viewed from the front of the rack). (PRD 6.2.5.2.2B)

C. Vibration Isolation

The fan shall be mounted with a Vibration Isolation Gasket between the fan and the chassis. Reference NASA/JSC drawing SDG 46116118 for an example of an approved vibration absorbing gasket. (PRD 6.2.5.2.2C)

D. Fan Mounting

The fan mounting shall be such that the fan can be Intravehicular Activity (IVA) replaceable. This design is the responsibility of the hardware developer. Reference NASA/JSC drawing SEG 46116120 for an approved IVA replaceable fan design. (PRD 6.2.5.2.2D)

E. Fan Operating Voltage

Fans shall operate at a maximum voltage of 28 +0.5/-2.0 Vdc. (Modified PRD 6.2.5.2.2E)

F. Fan Speed Controller

The common fan shall be controlled to the lowest speed required to provide sufficient cooling air (32 °C inlet air temperature) to its instruments. This speed shall be determined by thermal analysis and HRF Systems Engineering and Integration. It is the hardware developer’s responsibility for the design of a fan speed controller if one is deemed necessary. Reference NASA/JSC drawing SEG46115961 for an approved fan speed controller. (PRD 6.2.5.2.2F)

A fan-to-heat exchanger close-out gasket between the Payload Drawer and the Rack Connector bar will be provided by the rack integrator and installed onto the rack connector bar. (HRF Engineering Directive ED-003)

4.5.2 Front Surface Temperature

The refrigerated centrifuge shall be designed such that the average front surface temperature is less than 37 °C (98.6 °F) with a maximum temperature limit not to exceed 48.89 °C (120 °F). (Modified PRD 6.2.5.3)

4.5.3 Cabin Air Heat Leak

Not Applicable.

4.5.4 Cabin Air Cooling

Not Applicable.

4.6 VACUUM SYSTEM REQUIREMENTS

Not Applicable. The refrigerated centrifuge does not require the vacuum system.

4.7 PRESSURIZED GAS INTERFACE REQUIREMENTS

Not Applicable. The refrigerated centrifuge does not interface with the pressurized gas systems provided by the ISS.

4.8 PAYLOAD SUPPORT SERVICES INTERFACES REQUIREMENTS

Not Applicable. The refrigerated centrifuge does not interface with the ISS water system, and therefore these requirements are not applicable to this design.

4.9 MATERIALS AND PARTS INTERFACE REQUIREMENTS

4.9.1 Materials and Parts Use and Selection

HRF rack dependent instruments shall use materials and parts that meet the materials requirements specified in NSTS 1700.7B, ISS Addendum. (PRD 6.2.11.1)

4.9.2 Commercial Parts

COTS parts used in HRF rack dependent instruments shall meet the materials requirements specified in NSTS 1700.7B, ISS Addendum. (PRD 6.2.11.2)

4.9.3 Cleanliness

HRF rack dependent instruments shall conform to Visibly Clean-Sensitive (VC-S) cleanliness requirements as specified in SN-C-0005. (PRD 6.2.11.4)

4.9.4 Fungus Resistant Material

HRF rack dependent instruments that are intended to remain on-orbit for more than one year shall use fungus resistant materials according to the requirements specified in SSP 30233, paragraph 4.2.10. (PRD 6.2.11.5)

4.10 FIRE PROTECTION INTERFACE REQUIREMENTS

HRF dependent instruments that have forced air circulation and are mounted in SIR drawer locations within the HRF rack are monitored by the HRF rack smoke detector. The ISS Portable Fire Equipment (PFE) is capable of extinguishing fires within these instrument volumes when discharged into the HRF rack PFE access port. These instruments do not require additional smoke detectors or PFE access ports. (Modified PRD 6.2.10)

4.10.1 Fire Prevention

The RC shall meet the fire prevention requirements specified in NSTS 1700.7B, ISS Addendum, paragraph 220.10a. (PRD 6.2.10.1)

4.10.2 Portable Fire Extinguisher

Not Applicable.

4.10.3 Fire Suppression Access Port Accessibility

Not Applicable.

4.10.4 Fire Suppressant Distribution

The internal layout of HRF rack dependent instruments shall allow ISS PFE fire suppressant to be distributed to the entire volume that PFE Access Port serves, lowering the oxygen concentration to or below 10.5% by volume at any point within the enclosure within one minute. (PRD 6.2.10.4)

5.0 GENERAL DESIGN REQUIREMENTS

The hardware controlled by this document shall comply with the general design requirements stated in this section. These requirements are present to help guide in the overall design of the hardware. The majority of the requirements in this section are derived from the HRF PRD, LS-71000.

5.1 HUMAN FACTORS

5.1.1 Strength Requirements

5.1.1.1 Operation and Control of Payload Equipment

A. Grip Strength

To remove, replace, and operate payload hardware, grip strength required shall be less than 254 N (57 lbf). (PRD 6.4.1.1A)

B. Linear Forces

Linear forces required to operate or control payload hardware or equipment shall be less than the strength values for the 5th percentile female, defined as 50% of the strength values shown in Figure 6.4.1-1 and 60% of the strength values shown in Figure 6.4.1-2 of LS-71000. (PRD 6.4.1.1B)

C. Torque

Torque required to operate or control payload hardware or equipment shall be less than the strength values for the 5th percentile female, defined as 60% of the calculated 5th percentile male capability shown in Figure 6.4.1-3 of LS-71000. (PRD 6.4.1.1C)

5.1.1.2 Maintenance Operations

Forces required for maintenance of payload hardware and equipment shall be less than the 5th percentile male strength values shown in Figures 6.4.1-1, 6.4.1-2, 6.4.1-3, 6.4.1-4, and 6.4.1-5 of LS-71000. (PRD 6.4.1.2)

5.1.2 Body Envelope and Reach Accessibility

5.1.2.1 Adequate Clearance

The payloads shall provide clearance for the crew to perform installation, operations, and maintenance tasks, including clearance for hand access, tools and equipment used in these tasks. (PRD 6.4.2.1)

5.1.2.2 Accessibility

A. Payload hardware shall be geometrically arranged to provide physical and visual access for all payload installation, operations, and maintenance tasks. Payload Orbital Replacement Units (ORUs) should be removable along a straight path until they have cleared the surrounding structure. (PRD 6.4.2.2A)

B. IVA clearances for finger access shall be provided as given in Figure 6.4.2.2-1 of LS-71000. (6.4.2.2B)

5.1.2.3 Full Size Range Accommodation

All payload workstations and hardware intended for crew nominal operations and planned maintenance shall be sized to meet the functional reach limits for the 5th percentile Japanese female, and yet shall not constrict or confine the body envelope for the 95th percentile American male as specified in SSP 50005, Section 3. (PRD 6.4.2.3)

5.1.3 Habitability

5.1.3.1 Housekeeping

5.1.3.1.1 Closures or Covers

Closures or covers shall be provided for any area of the payload that is not designed for routine cleaning. (PRD 6.4.3.1.1)

5.1.3.1.2 Built-In Control

A. Payload containers of liquids or particulate matter shall have built-in equipment/methods for control of vaporization, material overflow, or spills. (PRD 6.4.3.1.2A)

B. The capture elements, including grids, screens, or filter surfaces shall be accessible for replacement or cleaning without dispersion of the trapped materials. (6.4.3.1.2B)

5.1.3.1.3 One-Handed Operation

Cleaning equipment and supplies shall be designed for one-handed operation or use. (PRD 6.4.3.1.3)

5.1.3.1.4 Surface Materials

Materials used for exposed interior surfaces shall be selected to preclude particulate and microbial contamination and shall be smooth, solid, and non-porous. (PRD 6.4.3.1.4)

5.1.3.2 Touch Temperature

5.1.3.2.1 Continuous/Incidental Contact - High Temperature

Not Applicable. Surface temperatures do not exceed 120 °F.

5.1.3.2.2 Continuous/Incidental Contact - Low Temperature

When payload surfaces below -18 °C (0 °F), which are subject to continuous or incidental contact, are exposed to the crewmember’s bare skin contact, protective equipment shall be provided to the crew, and warning labels shall be provided at the surface site. (modified PRD 6.4.3.2.2)

5.1.3.3 Acoustic Requirements

5.1.3.3.2 Intermittent Noise Limits

A. The Integrated rack (including any supporting adjunct active portable equipment operated outside the integrated rack that is within or interfacing with the crew habitable volume) Intermittent Noise Source shall not exceed the Total Rack A-weighted Sound Pressure Level Limits during the Maximum Rack Noise Duration as specified in Table 5.1.3.3.2-1 when the equipment is operating in the loudest expected configuration and mode of operation that can occur on orbit under any planned operations (PRD 6.4.3.3.2A)

NOTE: These acoustic requirements do not apply during failure or maintenance operations.

TABLE 5.1.3.3.2-1. INTERMITTENT NOISE LIMITS

Rack Noise Limits Measured at 0.6 meters distance from the test article	
Maximum Rack Noise Duration U	Total Rack A-weighted SPL (dBA)
8 Hours	49
7 Hours	50
6 Hours	51
5 Hours	52
4 Hours	54
3 Hours	57
2 Hours	60
1 Hour	65
30 Minutes	69
15 Minutes	72
5 Minutes	76
2 Minutes	78
1 Minute	79
Not Allowed	80

B. The Rack Noise Duration is the total time that the rack produces intermittent noise above the NC-40 limit during a 24 hour time period. This duration is the governing factor in determining the allowable Intermittent Noise Limits. Regardless of the number of separate sources and varying duration within a rack, this cumulative duration shall be used to determine the A-weighted SPL limit in column B. (PRD 6.4.3.3.2B)

C. For example, if a rack produces 65 dBA for 30 minutes in a start-up and warm-up mode and then settles down to 60 dBA for a one hour period of normal data acquisition, the duration is 1.5 hours. To meet the requirement, the noise can be no greater than 60 dBA, and in this case, the rack would not meet the requirement, even though two separate payloads, one that operated at 65 dBA for 30 minutes and another that operated at 60 dBA for one hour, would be acceptable (see Figure 5.1.3.3.2-1). (PRD 6.4.3.3.2C)

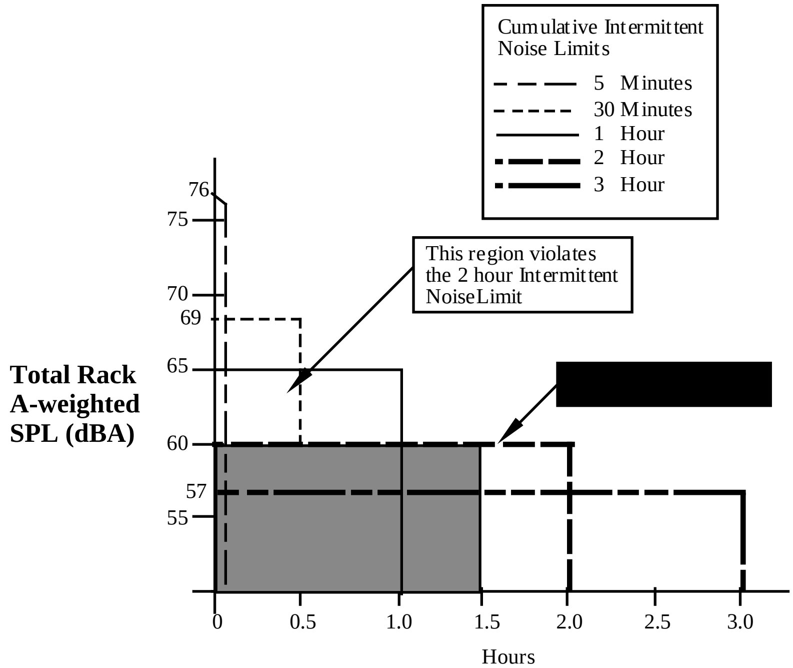


Figure 5.1.3.3.2-1. Intermittent Noise Limits

5.1.4 Lighting Design

Not Applicable.

5.1.5 Color Schemes

5.1.5.1 Rack Mounted Equipment

SSP 50008, Rev. B, page 3-4, Table 3.2.7-1, applies to HRF rack mounted hardware. Front panels for active and stowage drawers meant for installation in HRF racks shall be off-white, specification # 27722 as given in FED-STD-595B, “Federal Standard Colors Used in Government Procurement.” The finish shall be semi-gloss. SIR drawer panel handle latches are not subject to this requirement and shall be finished in accordance with the engineering drawings for the panel handle latches.
(PRD 6.4.3.5.1)

5.1.5.2 Stowed/Deployable Equipment

Not Applicable.

5.1.5.3 Colors for Soft Goods

Not Applicable.

5.1.6 Structural/Mechanical Interfaces

5.1.6.1 Hardware Protrusion Limits

5.1.6.1.1 Permanent Protrusions

Not Applicable.

5.1.6.1.2 Intermittent Protrusions

Not Applicable.

5.1.6.1.3 Temporary Protrusions

Temporary protrusions are defined as equipment, which remains set up in the aisle for a period of less than eight hours, during which time crew attendance will be nearly continuous. Temporary protrusions shall be limited to 26 inches beyond the plane of the NASA ISPR. (PRD 6.4.4.1.3)

5.1.6.1.4 Clearance for Crew Restraints and Mobility Aids

Not Applicable.

5.1.6.1.5 Fire Suppression Port Access

Not Applicable.

5.1.6.2 Payload Hardware Mounting

5.1.6.2.1 Equipment Mounting

Equipment items used during nominal operations and planned maintenance shall be designed, labeled, or marked to protect against improper installation. (PRD 6.4.4.2.1)

5.1.6.2.2 Drawers and Hinged Panels

A. Payload ORUs which are pulled out of their installed positions for routine checkout shall be mounted on equipment drawers or on hinged panels. (PRD 6.4.2.2A)

B. Such drawers or hinged panels shall remain in the open position without being supported by hand. (PRD 6.4.4.2.2B)

5.1.6.2.3 Alignment

Payload hardware having blind mate connectors shall provide guide pins or their equivalent to assist in alignment of hardware during installation. (PRD 6.4.4.2.3)

5.1.6.2.4 Slide-Out Stops

Limit stops shall be provided on slide or pivot mounted sub-rack hardware, which is required to be pulled out of its installed positions. (PRD 6.4.4.2.4)

5.1.6.2.5 Push-Pull Force

Payload hardware mounted into a capture-type receptacle that requires a push-pull action shall require a force less than 156 N (35 lbf) to install or remove. (PRD 6.4.4.2.5)

5.1.6.2.6 Access

Access to inspect or replace a hardware item (e.g., an ORU), which is planned to be accessed on a daily or weekly basis, shall not require removal of another hardware item or more than one access cover. (PRD 6.4.4.2.6)

5.1.6.2.6.1 Covers

Where physical access is required, one of the following practices shall be followed, with the order of preference given.

A. Provide a sliding or hinged cap or door where debris, moisture, or other foreign materials might otherwise create a problem. (6.4.4.2.6.1A)

B. Provide a quick-opening cover plate if a cap will not meet stress requirements. (PRD 6.4.4.2.6.1B)

5.1.6.2.6.2 Self-Supporting Covers

All access covers that are not completely removable shall be self-supporting in the open position. (PRD 6.4.4.2.6.2)

5.1.6.2.6.3 Unique Tools

Payload provided unique tools shall meet the requirements of SSP 50005, paragraph 11.2.3. (PRD 6.4.4.2.6.3)

5.1.6.3 Connectors

5.1.6.3.1 One-Handed Operation

All ORU connectors, whether operated by hand or tool, shall be designed and placed so they can be mated/demated using either hand. (PRD 6.4.4.3.1)

5.1.6.3.2 Accessibility

A. It shall be possible to mate/demate individual connectors without having to remove or mate/demate other connectors during nominal operations. (PRD 6.4.4.3.2A)

B. It shall be possible to mate/demate individual connectors without having to remove or mate/demate connectors on other ORUs or payloads during maintenance operations. (PRD 6.4.4.3.2B)

C. Electrical connectors and cable installations shall permit disconnection and reconnection without damage to wiring connectors. (PRD 6.4.4.3.2C)

5.1.6.3.3 Ease of Disconnect

Electrical connectors shall require no more than two turns to disconnect. (PRD 6.4.4.3.3)

5.1.6.3.4 Indication of Pressure/Flow

Not Applicable.

5.1.6.3.5 Self Locking

Payload electrical connectors shall provide a self-locking feature. (PRD 6.4.4.3.5)

5.1.6.3.6 Connector Arrangement

A. Space between connectors and adjacent obstructions shall be a minimum of 25 mm (1 inch) for IVA access. (PRD 6.4.4.3.6A)

B. Connectors in a single row or staggered rows which are removed sequentially by the crew IVA shall provide 25 mm (1 inch) of clearance from other connectors and/or adjacent obstructions for 270 degrees of sweep around each connector beginning at the start of its removal/replacement sequence. (PRD 6.4.4.3.6B)

5.1.6.3.7 Arc Containment

Electrical connector plugs shall be designed to confine/isolate the mate/demate electrical arcs or sparks. (PRD 6.4.4.3.7)

5.1.6.3.8 Connector Protection

Protection shall be provided for all demated connectors against physical damage and contamination. (PRD 6.4.4.3.8)

5.1.6.3.9 Connector Shape

Payload connectors shall use different connector shapes, sizes, or keying to prevent mating connectors when lines differ in content. (PRD 6.4.4.3.9)

5.1.6.3.10 Fluid and Gas Line Connectors

Not Applicable.

5.1.6.3.11 Alignment Marks or Guide Pins

Mating parts shall have alignment marks in a visible location during mating or guide pins (or their equivalent). (PRD 6.4.4.3.11A)

5.1.6.3.12 Coding

A. Both halves of mating connectors shall display a code or identifier which is unique to that connection. (PRD 6.4.4.3.12A)

B. The labels or codes on connectors shall be located so they are visible when connected or disconnected. (PRD 6.4.4.3.12B)

5.1.6.3.13 Pin Identification

Each pin shall be uniquely identifiable in each electrical plug and each electrical receptacle. At least every 10th pin must be labeled "Not Applicable to COTS Connectors." (Modified PRD 6.4.4.3.13)

5.1.6.3.14 Orientation

Not Applicable.

5.1.6.3.15 Hose/Cable Restraints

Not Applicable. There are no external hoses or cables associated with the RC System.

5.1.6.4 Fasteners

5.1.6.4.1 Non-Threaded Fasteners Status Indication

An indication of correct engagement (hooking, latch fastening, or proper positioning of interfacing parts) of non-threaded fasteners shall be provided. (PRD 6.4.4.4.1)

5.1.6.4.2 Mounting Bolt/Fastener Spacing

Clearance around fasteners to permit fastener hand threading (if necessary) shall be a minimum of 0.5 inches for the entire circumference of the bolt head and a minimum of 1.5 inches over 180 degrees of the bolt head and shall provide the tool handle sweep as seen in Figure 6.4.4.4.2-1 of LS-71000. Excepted are NSTS standard middeck lockers or payload-provided hardware with the static envelope dimensions (cross-section) as specified in Figures 3.4.2.1-1, 3.4.2.2-1 and 3.4.2.3-1 of NSTS-21000-IDD-MDK and other similar captive fastener arrangements. (PRD 6.4.4.4.2)

5.1.6.4.3 Multiple Fasteners

When several fasteners are used on one item they shall be of identical type. (PRD 6.4.4.4.3)

<u>NOTE</u>: Phillips or torque-set fasteners may be used where fastener installation is permanent relative to planned on-orbit operations or maintenance, or where tool-fastener interface failure can be corrected by replacement of the unit containing the affected fastener with a spare unit.

5.1.6.4.4 Captive Fasteners

All fasteners planned to be installed and/or removed on-orbit shall be captive when disengaged. (PRD 6.4.4.4.4)

5.1.6.4.5 Quick Release Fasteners

A. Quick release fasteners shall require a maximum of one complete turn to operate (quarter-turn fasteners are preferred). (PRD 6.4.4.4.5A)

B. Quick release fasteners shall be positive locking in open and closed positions. (PRD 6.4.4.4.5B)

5.1.6.4.6 Threaded Fasteners

Only right handed threads shall be used. (PRD 6.4.4.4.6)

5.1.6.4.7 Over Center Latches

A. Non-self latching - Over center latches shall include a provision to prevent undesired latch element realignment, interface, or reengagement. (PRD 6.4.4.4.7A)

B. Latch lock - Latch catches shall have locking features. (PRD 6.4.4.4.7B)

C. Latch handles - If the latch has a handle, the latch handle and latch release shall be operable by one hand. (PRD 6.4.4.4.7C)

5.1.6.4.8 Winghead Fasteners

Not Applicable. (PRD 6.4.4.4.8)

5.1.6.4.9 Fastener Head Type

A. Hex type external or internal grip or combination head fasteners shall be used where on-orbit crew actuation is planned, e.g., ORU replacement. (PRD 6.4.4.4.8A)

B. If a smooth surface is required, flush or oval head internal hex grip fasteners shall be used for fastening. (PRD 6.4.4.4.9B)

C. Slotted fasteners shall not be used to carry launch loads for hard-mounted equipment. Slotted fasteners are allowed in non-structural applications (e.g., computer data connectors, stowed commercial equipment). (PRD 6.4.4.4.9C)

5.1.6.4.10 One-Handed Actuation

Fasteners planned to be removed or installed on-orbit shall be designed and placed so they can be mated/demated using either hand. (PRD 6.4.4.4.10)

5.1.6.4.11 Accessibility

IVA fasteners shall be separated to provide hand and tool clearance in accordance with Figure 6.4.4.4.2-1 in LS-71000. (PRD 6.4.4.4.11)

5.1.6.4.12 Access Holes

Covers or shields through which mounting fasteners must pass for attachment to the basic chassis of the unit shall have holes for passage of the fastener without precise alignment (and hand or necessary tool if either is required to replace). (PRD 6.4.4.4.12)

5.1.7 Controls and Displays

5.1.7.1 Controls Spacing Design Requirements

All spacing between controls and adjacent obstructions shall meet the minimum requirements as shown in Figure 6.4.5.1-1, Control Spacing Requirements for Ungloved Operation, in LS-71000. (PRD 6.4.5.1)

5.1.7.2 Accidental Actuation

Requirements for reducing accidental actuation of controls are defined in the following paragraphs:

5.1.7.2.1 Protective Methods

Payloads shall provide protection against accidental control actuation using one or more of the protective methods listed in sub-paragraphs A through G below. Infrequently used controls (i.e., those used for calibration) should be separated from frequently used controls. Leverlock switches or switch covers are strongly recommended for switches related to mission success. Switch guards may not be sufficient to prevent accidental actuation. (PRD 6.4.5.2.1)

NOTE: Displays and controls used only for maintenance and adjustments, which could disrupt normal operations if activated, should be protected during normal operations, e.g., by being located separately or guarded/covered.

A. Locate and orient the controls so that the operator is not likely to strike or move them accidentally in the normal sequence of control movements. (A)

B. Recess, shield, or otherwise surround the controls by physical barriers. The control shall be entirely contained within the envelope described by the recess or barrier. (B)

C. Cover or guard the controls. Safety or lock wire shall not be used. (C)

D. Cover guards when open shall not cover or obscure the protected control or adjacent controls. (D)

E. Provide the controls with interlocks so that extra movement (e.g., lifting switch out of a locked detent position) or the prior operation of a related or locking control is required. (E)

F. Provide the controls with resistance (i.e., viscous or coulomb friction, spring-loading, or inertia) so that definite or sustained effort is required for actuation. (F)

G. Provide the controls with a lock to prevent the control from passing through a position without delay when strict sequential actuation is necessary (i.e., the control is moved only to the next position, then delayed). (G)

5.1.7.2.2 Noninterference

Payload provided protective devices shall not cover or obscure other displays or controls. (PRD 6.4.5.2.2)

5.1.7.2.3 Dead-Man Controls

Dead-man controls are covered under NSTS 1700.7B, ISS Addendum paragraphs 200.4a and 303.2. (PRD 6.4.5.2.3)

5.1.7.2.4 Barrier Guards

Barrier guard spacing shall adhere to the requirements for use with the toggle switches, rotary switches, and thumbwheels as shown in Figures 6.4.5.1-1, Control Spacing Requirements for Ungloved Operation, and 6.4.5.2.3-1, Rotary Switch Guard, in LS-71000. (PRD 6.4.5.2.4)

5.1.7.2.5 Recessed Switch Protection

When a barrier guard is not used, rotary switches that control critical functions shall be recessed as shown in Figure 6.4.5.2.3-1, Rotary Switch Guard, in LS-71000. (PRD 6.4.5.2.5)

5.1.7.2.6 Position Indication

When payload switch protective covers are used, the control position shall be evident without requiring cover removal. (PRD 6.4.5.2.7)

5.1.7.2.7 Hidden Controls

Controls that cannot be directly viewed will be avoided. If present, hidden controls shall be guarded to protect against inadvertent actuation. (PRD 6.4.5.2.8)

5.1.7.2.9 Hand Controllers

Not Applicable.

5.1.7.3 Valve Controls

Not Applicable.

5.1.7.4 Restraints and Mobility Aids

Not Applicable.

5.1.8 <u>Identification Labeling</u>

Integrated racks, all (installed in the rack or separately) sub-rack elements, loose equipment, stowage trays, consumables, ORUs, crew accessible connectors and cables, switches, indicators, and controls shall be labeled. Labels are markings of any form (including Inventory Management System (IMS) bar codes) such as decals and placards, which can be adhered, “silk screened,” engraved, or otherwise applied directly onto the hardware. Appendix C provides instructions for label and decal design and approval. (PRD 6.4.7)

5.1.9 <u>Crew Safety</u>

(Review with 4.2.2.14 to see if these are duplicate requirements)

5.1.9.1 Electrical Hazards

Electrical equipment, other than bioinstrumentation equipment, will incorporate the following controls as specified below:

A. If the exposure condition is below the threshold for shock (i.e., below maximum leakage current and voltage requirements as defined within this section), no controls are required. Non-patient equipment with internal voltages not exceeding 30 volts rms or DC nominal (32 volts rms or DC maximum) will contain potentials below the threshold for electrical shock. (PRD 6.4.9.1A)

B. If the exposure condition exceeds the threshold for shock, but is below the threshold of the let-go current profile (critical hazard) as defined in Table 5.1.9.1-1, two independent controls (e.g., a safety (green) wire, bonding, insulation, leakage current levels below maximum requirements) shall be provided such that no single failure, event, or environment can eliminate more than one control. (PRD 6.4.9.1B)

C. If the exposure condition exceeds both the threshold for shock and the threshold of the let-go current profile (catastrophic hazardous events) as defined in Table 5.1.9.1-1, three independent controls shall be provided such that no combination of two failures, events, or environments can eliminate more than two controls. (PRD 6.4.9.1C)

TABLE 5.1.9.1-1. LET-GO CURRENT PROFILE, THRESHOLD VERSUS FREQUENCY

Frequency	Maximum Total Peak Current (AC + DC Components Combined) Milliamperes
DC	40.0
15	8.5
2000	8.5
3000	13.5
4000	15.0
5000	16.5
6000	17.9
7000	19.4
8000	20.9
9000	22.5
>10000	24.3

(SSP 57000C, TABLE 3.12.9.1-1)

D. If two dependent controls are provided, the physiological effect that a crew member experiences as a result of the combinations of the highest internal voltage applied to or generated within the equipment and the frequency and wave form associated with a worst case credible failure shall be below the threshold of the let-go current profile as defined in Table 5.1.9.1-1. (6.4.9.1D)

E. If it cannot be demonstrated that the hazard meets the conditions of paragraph A, B, or C above, three independent hazard controls shall be provided such that no combination of two failures, events, or environments can eliminate more than two controls. (6.4.9.1E)

5.1.9.1.1 Mismatched

A. The design of electrical connectors shall make it impossible to inadvertently reverse a connection or mate the wrong connectors if a hazardous condition can be created. (PRD 6.4.9.1.1A)

B. Payload and on-orbit support equipment, wire harnesses, and connectors shall be designed such that no blind connections or disconnections can be made during payload installation, operation, removal, or maintenance on orbit, unless the design includes scoop proof connectors or other protective features (NSTS 1700.7B, ISS Addendum, paragraph 221). (PRD 6.4.9.1.1B)

C. For payload equipment, for which mismating or cross-connection may damage ISS-provided equipment, plugs and receptacles (connectors) shall be selected and applied such that they cannot be mismatched or cross-connected in the intended system, as well as adjacent systems. Although identification markings or labels are required, the use of identification alone is not sufficient to preclude mismating. (PRD 6.4.9.1.1C)

D. For all other payload connections, combinations of identification, keying and clocking, and equipment test and checkout procedures shall be employed at the payload's discretion to minimize equipment risk while maximizing on-orbit operability. (PRD 6.4.9.1.1D)

5.1.9.1.2 Overload Protection

5.1.9.1.2.1 Device Accessibility

An overload protective device shall not be accessible without opening a door or cover, except for an operating handle or operating button of a circuit breaker, the cap of an extractor-type fuse holder, and similar parts that may project outside the enclosure. (PRD 6.4.9.1.2.1)

5.1.9.1.2.2 Extractor Type Fuse Holder

Not Applicable.

5.1.9.1.2.3 Overload Protection Location

Overload protection devices (fuses and circuit breakers) intended to be manually replaced or physically reset on-orbit shall be located where they can be seen and replaced or reset without removing other components. (PRD 6.4.9.1.2.3)

5.1.9.1.2.4 Overload Protection Identification

Each overload protector (fuse or circuit breaker) intended to be manually replaced or physically reset on-orbit shall be readily identified or keyed for its proper value. (PRD 6.4.9.1.2.4)

5.1.9.1.2.5 Automatic Restart Protection

Controls shall be employed that prevent automatic restarting after an overload-initiated shutdown. (PRD 6.4.9.1.2.4)

5.1.9.2 Sharp Edges and Corners Protection

Payload design within a pressurized module shall protect crewmembers from sharp edges and corners during all crew operations in accordance with SSP 50005 paragraph 6.3.3. (PRD 6.4.9.2)

5.1.9.3 Holes

Holes that are round or slotted in the range of 10.0 to 25.0 mm (0.4 to 1.0 in) shall be covered. (PRD 6.4.9.3)

5.1.9.4 Latches

Latches that pivot, retract, or flex so that a gap of less than 35 mm (1.4 in) exists shall be designed to prevent entrapment of a crewmember's appendage. (PRD 6.4.9.4)

5.1.9.5 Screws and Bolts

Threaded ends of screws and bolts accessible by the crew and extending more than 3.0 mm (0.12 in) shall be capped to protect against sharp threads. (PRD 6.4.9.5)

5.1.9.6 Securing Pins

Securing pins shall be designed to prevent their inadvertently backing out above the handhold surface. (PRD 6.4.9.6)

5.1.9.7 Levers, Cranks, Hooks, and Controls

Not Applicable.

5.1.9.8 Burrs

Exposed surfaces shall be free of burrs. (PRD 6.4.9.8)

5.1.9.9 Locking Wires

Not Applicable. Lock wire is prohibited on ISS.

5.1.9.10 Audio Devices (Displays)

Not Applicable.

5.1.9.11 Egress

All payload egress requirements shall be in accordance with NSTS 1700.7B, ISS Addendum, paragraph 205. (PRD 6.4.9.11)

5.1.10 Payload In-Flight Maintenance

Payloads shall be designed to be maintainable using Space Station provided on-board tools. A list of available tools on-orbit is defined in the Payload Accommodations Handbook. (PRD 6.4.10)

5.2 CONSTRUCTION REQUIREMENTS

5.2.1 Materials and Processes

5.2.1.1 General Materials, Processes, and Parts Interface

Materials and processes shall meet the requirements of SE-M-0096A, "General Specification for Materials and Processes, Requirements for JSC Controlled Payloads."

5.2.1.2 Fracture/Fatigue

The refrigerated centrifuge shall be designed to prevent the creation or propagation of any material failures per the requirements of LS-71010, "Fracture Control Plan for the Human Research Facility."

5.2.2 Screw Threads

All straight screw threads shall be in accordance with MIL-S-7742B, "General Specification for Screw Threads, Standard, Optimum Selected Series," and/or MIL-S-8879A, "General Specification for Screw Threads, Controlled Radius Root With Increased Minor Diameter."

5.2.3 Fasteners

All fasteners shall be purchased with material certification information included in the delivery and placed in a controlled storage facility. Any fastener over the size designation of a number 8 shall be tested per the requirements of JSC-23642, "JSC Fastener Integrity Testing Program."

Due to the extensive use of COTS hardware systems, implementation of this requirement is not absolute, particularly for non-structural members. In these cases, non-adherence must be reviewed with and approved by the JSC Structures and Mechanics Working Group.

5.2.4 Locking Devices

5.2.4.1 Thread Locking Adhesive

Any liquid locking substance shall be applied per MIL-S-33540, "General Specification for Liquid Locking Compounds."

5.2.4.2 Lock Wire

Not Applicable. Lock wire is prohibited on ISS.

5.3 WORKMANSHIP

Workmanship shall be of aerospace quality and shall conform to high grade aerospace manufacturing practices as directed by LS-71030, "Quality Assurance Plan for the Human Research Facility."

5.4 INTERCHANGEABILITY AND REPLACEABILITY

Interchangeability requirements are not applicable to detail parts of permanent assemblies such as welded assemblies or matched detailed parts such as lapped components. Interchangeability requirements do not apply to custom-fitted or custom-sized items.

All replaceable parts or assemblies having the same part number shall be directly and completely interchangeable with each other, with respect to form, fit, and function.

5.4.1 Maintainability On-Orbit

The centrifuge chamber will be wiped down after each spin with a Station provided disinfectant wipe. Any spills will be cleaned up in accordance with the experiment protocol. The crew will also need to swab up any condensation that was formed in the chamber with Station provided dry wipes.

The o-ring around the rotor chamber will be checked for damage periodically and replaced when necessary. This maintenance task requires no tools. At present, there is no way to calibrate the centrifuge. The drift of the rotor motor may be measured on orbit, but there is no way to correct this drift. Each assembly shall be designed to be replaceable without requiring the removal of other components or assemblies.

5.4.2 Ground Maintainability

Describe what will need to be done on the ground to keep the hardware functioning (i.e., ground calibration, etc.…). State requirements as “shall,” general operation instructions should not be written as requirements.

5.5 USEFUL LIFE

The useful life of the equipment (equivalent to full life) is the sum of operational life and shelf life. This requirement is imposed by the HRF PRD. The refrigerated centrifuge useful life shall be a minimum of 10 years.

5.5.1 Operational Life (Cycles)

Operational life applies to any hardware that deteriorates with the accumulation of operating time and/or cycles and thus requires periodic replacement or refurbishment to maintain acceptable operating characteristics. Operational life includes the usage during flight, ground testing, and pre-launch operations. All components of the refrigerated centrifuge shall have an operational life limit of 10 years, except those identified as having limited life, see Section 5.5.3.

5.5.2 Shelf Life

Shelf life is defined as that period of time during which the components of a system can be stored under controlled conditions and put into service without replacement of parts (beyond servicing and installation of consumables). The refrigerated centrifuge has a shelf life limit of TBD.

5.5.3 Limited Life

Limited life is defined as the life of a component, subassembly, or assembly that expires prior to the stated useful life in Section 5.5 of this HRD. Limited life items or materials, such as soft goods, shall be identified, and the number of operation cycles shall be determined. Limited life items shall be tracked on a limited life list that is maintained as a part of the hardware acceptance data pack.

5.6 ELECTRICAL, ELECTRONIC, AND ELECTROMAGNETIC (EEE) PARTS REQUIREMENTS

5.6.1 General Requirements

Parts shall be controlled in accordance with:

A. NHB 5300.4(1F), “Electrical, Electronic, and Electromechanical (EEE) Parts Management and Control Requirements for NASA Space Flight Programs.”

B. SSP 30312, “Electrical, Electronic, and Electromechanical (EEE) and Mechanical Parts Management and Implementation Plan for Space Station Program.”

5.6.2 Part Selection

Part selection shall be in accordance with:

A. MIL-STD-975, (NASA), “NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts List.”

B. SSP-30423, “Space Station Approved Electrical, Electronic, and Electromechanical (EEE) Parts List.”

C. SSQ-25002, “Supplemental List of Qualified Electrical, Electronic, Electromechanical (EEE) Parts, Manufacturers, and Laboratories (QEPM&L).”

D. Semiconductors shall be JANTXV in accordance with MIL-S-19500, “General Specifications for Semiconductor Devices.” Diodes shall have a metallurgical bond. Passive parts shall be at least the second highest level of appropriate Military Established Reliability.

E. SSP-30512C, “Space Station Ionizing Radiation Design Environment.”

5.6.3 Commercial-Off-the-Shelf /Modified Commercial-Off-the-Shelf

To the extent practical, COTS and modified COTS must meet the above requirements to assure the hardware/design compliance to the EEE part selection criteria for the proposed applications and corresponding criticalities. This includes a risk assessment, electrical stress analysis, and data delivery on information such as designed/as-built EEE parts, list, construction history, Government and Industry Data Exchange Program (GIDEP) Alerts, part obsolescence, radiation susceptibility, and/or prior history.

Where no alternative is available, nonmilitary parts, components, and subassemblies may be used, but screening of these items shall be accomplished through burn-in. Screening shall be completed (100%) on all flight hardware (units).

Burn-in may be accomplished at the component or assembly level. Burn-in is specified as:

A. 72 hours continuously at room ambient temperature while functioning.

B. 96 hours continuously at a specified controlled temperature while functioning.

Controlled temperature is defined as 15 °C below the maximum rating of the device with the lowest temperature rating in the article.

5.7 BATTERY REQUIREMENTS

Not Applicable.

6.0 ENVIRONMENTAL DESIGN REQUIREMENTS

6.1 GENERAL

The RC shall be designed to meet the performance requirements during and after exposure to the environments specified below. The requirement levels listed below originate from the HRF PRD, except in those cases where certain environments have been established by appropriate JSC test, structural, or thermal organizations. In these cases, the hardware will meet the requirements so established. The specific method of compliance for each of the following requirements is described in the Verification Matrix found in Appendix B as well as in the appropriate sections below.

6.1.1 Atmosphere Requirements

6.1.1.1 Pressure

Rack dependent instruments shall be safe when exposed to pressures of 0 to 104.8 kPa (0 to 15.2 psia). (PRD 6.2.9.1.1))

6.1.1.2 Temperature

Rack dependent instruments shall be safe when exposed to temperatures of 10 to 46 °C (50 to 115 °F). (PRD 6.2.9.1.2)

6.1.1.3 Humidity

Rack dependent instruments shall be designed to not cause condensation when exposed to a dewpoint of 4.5 to 15.6 °C (40 to 60 °F) and a relative humidity of 25 to 75%, except when condensation is an intended operation of the instrument. (PRD 6.2.1.9.3)

6.1.2 Instrument Use of Cabin Atmosphere

6.1.2.1 Active Air Exchange

Not Applicable.

6.1.2.2 Oxygen Consumption

Not Applicable.

6.1.2.3 Chemical Releases

Chemical releases to the cabin air shall be in accordance with paragraphs 209.1a and 209.1b in NSTS 1700.7B, ISS Addendum. (PRD 6.2.9.3)

6.1.3 Ionizing Radiation Requirements

6.1.3.1 Instrument Contained or Generated Ionizing Radiation

Not Applicable. (PRD 6.2.9.3.1)

6.1.3.2 Ionizing Radiation Dose

Instruments should expect a total dose (including trapped protons and electrons) of 30 rad (Si) per year of ionizing radiation. A review of the dose estimates in the ISS (SAIC-TN-9550) may show ionizing radiation exposure to be different than 30 rad (Si) per year, if the intended location of the rack in the ISS is known. (PRD 6.2.9.3.2)

6.1.3.3 Single Event Effect (SEE) Ionizing Radiation

Instruments shall be designed not to produce an unsafe condition or one that could cause damage to equipment as a result of exposure to SEE ionizing radiation assuming exposure levels specified in SSP 30512, paragraph 3.2.1, with a shielding thickness of 25.4 mm (1000 mils). (PRD 3.9.3.3)

6.1.3.4 Additional Environmental Conditions

The environmental information provided in Table 6.1.3.4-1, Environmental Conditions on ISS, is for design and analysis purposes. (PRD 6.2.9.3.4)

6.1.4 Ground Handling

6.1.4.1 Ground Handling Load Factors

6.1.4.1.1 Shock Criteria - Rack Mounted Hardware Only

Not Applicable.

6.1.4.1.2 Bench Handling

The RC shall meet the Bench Handling Requirements referenced in MIL-STD 810E, Section 516.4, I-3.6, Procedure 6 with the following modifications:

Test conditions of 26 drops will be altered to 2 drops. Surfaces, corners, and edges shall be identified in the test procedure.

6.2 LAUNCH LANDING LOADS

A. For design and qualification purposes, SIR drawer instruments shall maintain positive margins of safety for the MPLM ascent random vibration environment as defined in Table 6.2-1, “Random Vibration Criteria for HRF Rack Post-Mounted Equipment in the MPLM.” (PRD 6.2.1.1.3A)

B. SIR drawer instruments shall maintain positive margins of safety for the launch and landing conditions in the MPLM. For early design, the acceleration environment defined in Table 6.2-2, “HRF Rack Mounted Equipment Load Factors (Equipment Frequency 35 Hz),” will be used. These load factors will be superseded by load factors obtained through ISS-performed Coupled Loads Analysis as described in SSP 52005. (PRD 6.2.1.1.3B)

TABLE 6.1.3.4-1. ENVIRONMENTAL CONDITIONS ON ISS

Environmental Condition	Value
Atmospheric Conditions	
Pressure Extremes	0 to 104.8 kPa (0 to 15.2 psia)
Normal operating pressure	See Figure 3.9.3.4-1
Oxygen partial pressure	See Figure 3.9.3.4-1
Nitrogen partial pressure	See Figure 3.9.3.4-1
Dewpoint	4.4 to 15.6 °C (40 to 60 °F)
Percent relative humidity	25 to 75
Carbon dioxide partial pressure during normal operations with 6 crewmembers plus animals	24-hr average exposure 5.3 mm Hg Peak exposure 7.6 mm Hg
Carbon dioxide partial pressure during crew changeout with 11 crewmembers plus animals	24-hr average exposure 7.6 mm Hg Peak exposure 10 mm Hg
Cabin air temperature in USL, JEM, APM, and CAM	17 to 28 °C (63 to 82 °F)
Cabin air temperature in Node 1	17 to 31 °C (63 to 82 °F)
Air velocity	0.051 to 2.03 m/s (10 to 40 ft/min)
Airborne microbes	Less than 1000 CFU/m^3
Atmosphere particulate level	Average less than 1000,000 particles/ft^3 for particles less than 0.5 microns in size
MPLM Air Temperatures	Active Flights
Pre-Launch	14 to 30 °C (57.2 to 86 °F)
Launch/Ascent	20 to 30 °C (68 to 86 °F)
On-orbit (Cargo Bay + Deployment)	16 to 46 °C (60.8 to 114.8 °F)
On-orbit (On-Station)	16 to 43 °C (63 to 109.4 °F)
On-orbit (Retrieval + Cargo Bay)	11 to 45 °C (63 to 113 °F)
Descent/Landing	10 to 42 °C (50 to 107.6 °F)
Post-Landing	10 to 42 °C (50 to 107.6 °F)
Ferry Flight	15.5 to 30 °C (59.9 to 86 °F)
	Passive Flights
Pre-Launch	15 to 24 °C (59 to 75.2 °F)
Launch/Ascent	14 to 24 °C (57.2 to 75.2 °F)
On-orbit (Cargo Bay + Deployment)	24 to 44 °C (75.2 to 111.2 °F)
On-orbit (On-Station)	23 to 45 °C (73.4 to 113 °F)
On-orbit (Retrieval + Cargo Bay)	17 to 44 °C (62.6 to 111.2 °F)
Descent/Landing	13 to 43 °C (55.4 to 109.4 °F)
Post-Landing	13 to 43 °C (55.4 to 109.4 °F)
Ferry Flight	15.5 to 30 °C (59.9 to 86 °F)
Thermal Conditions	
USL module wall temperature	13 °C to 43 °C (55 °F to 109 °F)
JEM module wall temperature	13 °C to 43 °C (55 °F to 109 °F) TBR
APM module wall temperature	13 °C to 43 °C (55 °F to 109 °F) TBR
CAM module wall temperature	13 °C to 43 °C (55 °F to 109 °F) TBR
Other integrated payload racks	Front surface less than 37 °C (97 °F)
*Microgravity	
Quasi-Steady State Environment	See Figures 3.9.3.4-2, 3.9.3.4-3 and Table 3.9.3.4-2
Vibro-acoustic Environment	See Figure 3.9.3.4-4
General Illumination	108 Lux (10 FC) measured 30 inches from the floor in the center of the aisle

*NOTE: Data reflects best available information as of May, 1997. Does not include effects of CAM.

TABLE 6.2-1. RANDOM VIBRATION CRITERIA FOR HRF RACK POST MOUNTED EQUIPMENT IN THE MPLM.

Frequency	Level
20 Hz	0.005 g^2/Hz
20-70 Hz	+5.0 dB/oct
70-200 Hz	0.04 g^2/Hz
200-2000 Hz	-3.9 dB/oct
2000 Hz	0.002 g^2/Hz
Composite	4.4 grms

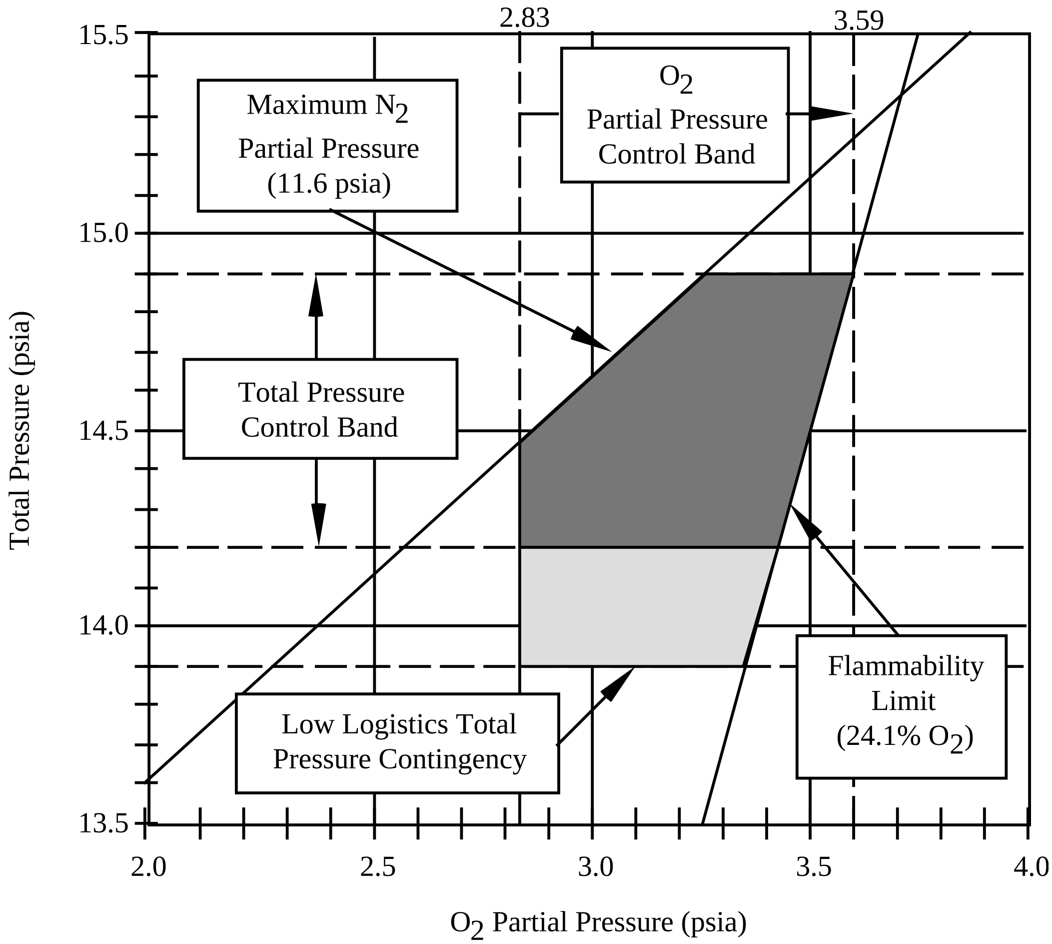
NOTE: Criteria is the same for all directions (X, Y, Z)

TABLE 6.2-2. HRF RACK MOUNTED EQUIPMENT LOAD FACTORS (EQUIPMENT FREQUENCY 35 MHZ)

Liftoff (g)	X ±7.7	Y ±11.6	Z ±9.9
Landing (g)	X ±5.4	Y ±7.7	Z ±8.8

NOTE: Load factors apply concurrently in all possible combinations for each event and are shown in the rack coordinate system.

NOTE: Load factors apply concurrently in all possible combinations for each event and are shown in the rack coordinate system.



(SSP 57000C, FIGURE 3.9.3.4-1)

Figure 6.2.9.3-1. Operating Limits of the ISS Atmospheric Total Pressure, and Nitrogen and Oxygen Partial Pressures

6.3 ON ORBIT LOADS

A. The RC shall provide positive margins of safety for launch and landing loading conditions in the transportation system, in which they are flown.

B. The RC shall provide positive margins of safety for on-orbit loads of 0.2 g acting in any direction. (PRD 6.2.1.1.4A)

C. The RC shall provide positive margins of safety when exposed to the crew-induced loads defined in Table 6.3-1, Crew-Induced Loads. (PRD 6.2.1.1.4B)

TABLE 6.3-1. CREW-INDUCED LOADS

Crew System Or Structure	Type Of Load	Load	Direction Of Load
Levers, Handles, Operating Wheels, Controls	Push or Pull concentrated on most extreme edge	222.6 N (50 lbf), limit	Any direction
Cabinets and any normally exposed equipment	Concentrated load applied by flat round surface with an area of 4 inch by 4 inch	556.4 N (125 lbf), limit	Any direction
Legend: ft = feet, m = meter, N = newton, lbf = pounds force			

(SSP 57000C, TABLE 3.1.1.3-1)

6.4 RANDOM VIBRATION

The hardware shall be designed to withstand the following launch level random vibration environment defined in Section 3.1.5.1 of SSP 52000. The table below is provided as reference only.

Location	Frequency	Level
Input rack to mounted equipment	20 Hz	.005 g^2/Hz
	20-70 Hz	+3.3 dB/oct
	70-200 Hz	0.02 g^2/Hz
	200-2000 Hz	-4.0 dB/oct
	2000 Hz	.00093 g^2/Hz
	Composite	3.1 g_{rms}
Legend: grms = gravity (g), root mean square oct = octave		

7.0 CERTIFICATION APPROACH

7.1 GENERAL

A formal design certification program shall be conducted to demonstrate that the refrigerated centrifuge meets all of the design requirements of this HRD. For the HRF program, certification has been established to encompass all of the acceptance and qualification procedures utilized to show compliance with the design requirements. All appropriate documentation resulting from this certification program shall be collected in a certification package (Section 7.3.3) and delivered to JSC Safety and Mission Assurance and engineering organizations for review and approval (i.e., Design Certification Review).

7.2 CERTIFICATION RATIONALE

Certification of the refrigerated centrifuge shall be by similarity, analysis, inspection, demonstration, and/or test at the component and/or the system level. The certification methods are described below.

7.2.1 Similarity

Certification data for hardware components previously qualified or flown shall be reviewed to verify that prior certification requirements meet or exceed the current mission requirements. The review shall cover structures, materials, environmental and operational requirements.

7.2.2 Analysis

Hardware not previously qualified or flown will be analyzed when analysis is the most efficient way to demonstrate capability to meet or exceed expected environmental conditions.

7.2.3 Inspection

The hardware shall be thoroughly inspected or reviewed to validate that it has been built to the individual assembly drawings. Inspection or review shall also be used when it is more efficient or applicable to demonstrate compliance to requirements rather than perform calculable testing or analysis.

7.2.4 Demonstration

The hardware shall be certified by observation that verified the design characteristics such as human factors, maintenance, operation, and access features. The pass/fail criterion of a demonstration is qualitative. Considering the design requirement, the operation or assessment shall be acceptable based upon the judgment of those approved individuals (i.e., quality assurance, human factors, astronaut, etc.) who witness the demonstration.

7.2.5 Test

The hardware shall be tested to verify that the design can withstand the environmental conditions and operate within the specified functional tolerances. Functional tests shall be performed before, during (if applicable), and after each environmental test. When testing is the chosen method, the tests shall be performed on appropriate hardware. All Class I hardware shall be subjected to test verifiable acceptance requirements. Qualification level requirement testing will use qualification hardware that is of identical configuration as the intended flight end items.

7.3 CERTIFICATION MATRIX

The certification matrix serves a dual purpose. For the HRD, this matrix indicates the acceptance/qualification compliance plan for each applicable requirement (see Appendix B). Once the project has completed all acceptance/qualification procedures on the qualification unit, a certification data pack shall be developed. At this stage, the certification matrix will be used as the certification compliance table. Serving as a basis or the certification report, the certification compliance table is attached to the front of the certification data package and provides closure status, reference material, and specific comments applicable to individual requirements.

7.3.1 Certification Plan

The overall certification plan for the refrigerated centrifuge is defined by the completed certification matrix in this HRD. The certification document column is left blank since the matrix is describing the plan, not the results. The matrix must detail how the requirements will be verified per the following:

1. If the requirement is for acceptance and/or qualification.
2. Which of the previously mentioned certification rationales will be applicable for fulfilling each requirement.
3. Which of the acceptance and/or qualification procedures will be applicable for fulfilling each requirement.
4. An explanation on the compliance procedure or plan in the comment column.
5. Identification of the hardware system test configuration in the comment field.

7.3.2 Certification Compliance

As certification data is completed (e.g., Task Performance Sheet (TPS), analysis, reports, waivers), verification information is added to the certification matrix. This version of the certification matrix is the method of reporting that all certification requirements have been properly met. It will replace a formal document type report and will be the basis of the certification package. The Certification Document column is filled in with documents number(s) (i.e., analysis reports or TPS) that describe how the design requirements were verified. Additional certification information is added to the Comments column as needed.

7.3.3 Certification Package

The hardware certification package consists of a Government Certification Approval Request (GCAR), the certification matrix containing the completed Compliance Certification column, and all back up information identified in the compliance table, such as TPSs, memos, analyses, software data files, and drawings. The GCAR is a subset of the Verification Compliance Data Package (VCDP). Contents of the VCDP are defined in SED QSI 3.7. They include the safety analysis (a preliminary hazard and operational hazard analysis) performed on the hardware.

7.4 TESTING PROGRAM

All certification tests (both qualification and acceptance type) described in the certification matrix require full quality coverage. Quality personnel must be notified, as required, prior to all certification test activities. Test Readiness Reviews (TRR) shall be held. It will be the responsibility of the test director and/or the program test coordinator to notify the appropriate personnel to participate in the TRR and attend the testing. Failure to notify quality personnel of a TRR could result in a delay or voiding of the certification test.

All testing and testing build-up shall be accomplished by TPS in accordance with LS-71030, "Quality Assurance Plan for the Human Research Facility."

For certification, functional tests shall be performed before, during (if applicable), and after major tests. These functional tests shall verify that the environment or level of the test had no detrimental effects on the hardware. All tests used for certification shall be approved by the JSC technical monitor and quality engineering.

In the event of a failure or non-conformance of a test article to its specified design requirement during the certification tests, perform the following sequence of events:

1. Halt the test.
2. Notify the Project Manager or his representative immediately.
3. Immediately initiate a Discrepancy Report (DR), which describes the failure or non-conformance condition and includes events preceding the observed failure. The test will continue at the discretion of the Project Manager or his representative and proper disposition of the DR.
4. The Test Control Board is convened to determine the type and cause of failure and establish corrective actions. The Board consists of the appropriate NASA project lead, hardware engineers, and quality and safety representatives.

The rejected item will be withheld from further certification testing until the reason for rejection is eliminated and remedial action has been described on the DR. On completion of remedial action, applicable acceptance tests shall be performed and pertinent certification tests repeated.

8.0 ACCEPTANCE APPROACH AND TESTS

8.1 GENERAL

An acceptance validation process shall be conducted on all parts, components, and assemblies to determine conformance to design specifications and to released drawings. This process shall include inspections on parts and materials and tests performed at intermediate points during production, final assembly, and during final shipment of the hardware.

An Acceptance Data Package (ADP) shall be provided for all flight end items.

1. The Statement of Work (SOW) for procured flight items shall contain a Data Requirements Document (DRD) specifying ADP contents using SSP 30695, Acceptance Data Package Requirements Specification, as a guideline.
2. Contents of the ADP for flight end items developed at JSC shall be documented in end item development plans using SSP 30695, Acceptance Data Package Requirements Specification, as a guideline. (PRD 7.3.3)

8.2 ACCEPTANCE TESTS

8.2.1 Pre-Delivery Acceptance (PDA) Test Requirements

A PDA shall be performed by the responsible manufacturing parties after the complete fabrication and assembly has been conducted for all Class I deliverable assemblies. This test shall include verification of software interface and operation. The PDA must be completed before hardware certification testing begins. It is a full functional test and inspection that validate that the hardware operates per the design requirements and that it is constructed per released engineering drawings and workmanship standards. All PDA tests shall be approved by the hardware JSC technical monitor and quality engineering, as well as the contractor quality engineering (if applicable). The following are standard steps that each PDA test shall contain:

1. Conformance to drawing. Verify that the hardware conforms to released engineering drawings.
2. No sharp edges. Inspect the hardware to verify that there are no sharp edges or corners present.
3. Proper identifying markings. Verify that the hardware has the proper part number and serial number (if applicable) on it .
4. Cleanliness. All PDA tests shall include verification that all surfaces (external, internal, etc.) are to the cleanliness level of Section 4.9.3 of this document.

8.2.2 Pre-Installation Acceptance (PIA) Test Requirements

PIA tests shall be conducted on all components and assemblies to determine conformance to design specifications as a basis for acceptance for flight usage. PIA tests shall be performed prior to shipment for flight after all certification testing and analyses are completed. PIA tests can also be performed upon post-shipment and/or pre-installation for flight.

8.2.3 Functional Test Requirements

Functional tests are performed to validate the operation of the hardware to the requirements of Section 3.1.2. Functionals make up the core of certain tests (like a PDA) and can be performed before and after environmental testing. The functional done prior to testing establishes the functional state (or baseline) of the hardware while the functional done after testing evaluates its ability to withstand the test levels.

An abbreviated functional will be used to test the functional state of the hardware during some environmental testing (i.e., thermal, vibration, bench handling, etc.). The intended use of an abbreviated functional is to verify nominal hardware functions between test stages.

8.2.4 Environmental Acceptance Test Requirements

Certain flight hardware will be exposed to environmental acceptance tests to verify workmanship and manufacturing and assembly conformance to drawings. The flight hardware that is exposed to vibration environments or is of significant complexity shall be exposed to an acceptance vibration test (AVT) level. The acceptance test levels for HRF hardware are defined in Section 8.2 of the HRF PRD.

NOTE: Soft goods and disposable items will not require environmental acceptance testing.

8.2.4.1 Acceptance Vibration Test

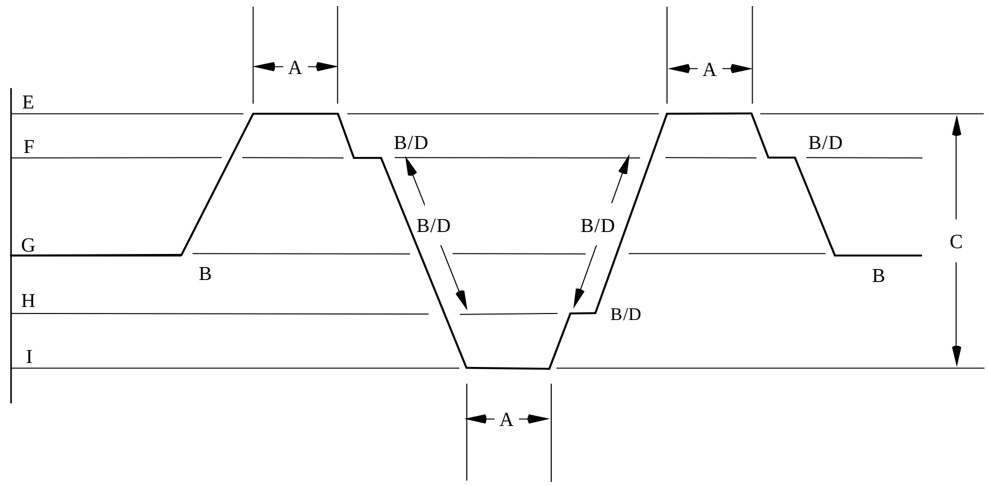
AVT is used to screen defects in workmanship that cannot be detected by inspection. If flight random vibration levels exceed minimum AVT vibration levels, AVT shall be conducted at the higher of the two levels specified by 1/1.69 times Qualification Vibration Test (QVT) levels or the minimum AVT levels shown below. Vibration duration shall be a minimum of 60 seconds in each of three axes. Minimum AVT levels are shown below. (PRD 5.4.1.1.3.3)

Frequency	Level
20 Hz	0.010 g^2/Hz
20-80 Hz	+3 dB/octave
80-350 Hz	0.04 g^2/Hz
350-2000 Hz	-3 dB/octave
2000 Hz	0.007 g^2/Hz
Composite	6.1 g RMS

8.2.4.2 Acceptance Thermal Cycle Test

An acceptance thermal cycle test shall be performed on all flight and flight alternate hardware. The acceptance thermal cycle shall be conducted over a temperature range of a 55.6 °C (100 °F) centered around the hardware normal operating temperature of 75 °F. The hardware shall be functionally tested before and after the temperature test, at each transition and at each stable temperature. The hardware shall not be functionally tested at temperatures in excess of the defined operating temperature range.

Figure 8.2.4.2-1 shows the test profile for acceptance thermal cycling. The complete test is one and one-half cycles with one hour soaks at each extreme.



NOTES:

1. A = Time to stabilize equipment temperature plus 1 hour.
2. B = Functional tests to be performed as shown.
3. C = Control temperature range between high and low acceptance test shall be a minimum of 55.56 °C (100 °F). Contractor is to specify tolerances on temperature periods.
4. D = Simplified functional test. Rate of temperature change during transition shall not be less than 0.55 °C (1 °F)/min or greater than 2.22 °C (4 °F).
5. E = Median operational temperature plus 27.78 °C (50 °F).
6. F = Maximum operational temperature.
7. G = Median operational temperature.
8. H = Minimum operational temperature.
9. I = Median operational temperature minus 27.78 °C (50 °F).

Figure 8.2.4.2-1. Acceptance Thermal Cycling

8.2.5 Electrical, Electronic, and Electromechanical Screening Tests

To the extent practical, COTS and modified COTS must meet the EEE requirements to assure the hardware/design compliance to the EEE part selection criteria for the proposed applications and corresponding criticality. This includes a risk assessment, electrical stress analysis, and data delivery on information such as designed/as-built EEE parts, list, construction history, Government and Industry Data Exchange Program (GIDEP) Alerts, part obsolescence, radiation susceptibility, and/or prior history.

Where no alternative is available, nonmilitary parts, components, and subassemblies may be used, but screening of these items shall be accomplished through burn-in. Screening shall be completed (100%) on all flight hardware (units).

Burn in may be accomplished at the component or assembly level. Burn-in shall be 72 hours continuously at room ambient temperature while functioning and 96 hours continuously at a specified controlled temperature while functioning.

Controlled temperature is defined as 15 °C below the maximum rating of the device with the lowest temperature rating in the article under test. (PRD 5.4.1.1.10)

8.2.6 <u>Safety Critical Structure Verification</u>

8.2.6.1 Safety Critical Structure Dimensional Check

All HRF flight hardware structural elements identified as safety critical structures shall be verified to be in accordance with the final design drawing dimensional requirements. The EXPRESS Rack verification will be provided by the supplier. (PRD 5.4.1.1.11.1)

8.2.6.2 Safety Critical Structure Material Certification

All structural elements that are identified as safety critical structures of each of the flight units shall use the components in those safety critical structures certified to be fabricated from the materials and alloys identified in the final design drawings and approved by NASA-JSC. (PRD 5.4.1.1.11.2)

8.3 SYSTEM INTEGRATION AND VERIFICATION REQUIREMENTS

The verification plans defined in this section shall be coordinated with JSC/NT and approved by the HRF Program prior to end item testing.

8.3.1 <u>Human Research Facility System Integration and Verification</u>

HRF hardware and software integration and verification for flight racks shall be in accordance with LS-71004, “System Integration and Verification Plan for the Human Research Facility.” (PRD 5.5.1)

8.3.2 <u>Human Research Facility Integrated Rack Verification Requirements</u>

Not Applicable.

8.3.3 <u>Refrigerated Centrifuge Verification Requirements</u>

Applicability of verification requirements for HRF instruments and Experiment Unique Equipment (EUE) shall be specified in the HRF instrument or EUE unique Software Requirements Document (SRD) verification matrix. Detailed verification requirements for instruments or EUE shall be specified in instrument and EUE unique Payload Verification Plan (PVP). The process for development of these plans is defined in the LS-71004, “Systems Integration and Verification Plan for the Human Research Facility,” paragraph 4.0. (PRD 5.5.3)

9.0 QUALIFICATION APPROACH AND TESTS

9.1 GENERAL

The following sections list the qualification testing levels for several of the natural environments listed in Section 6 of this HRD. This information shall be included in the comments column of the certification matrix in Appendix B.

9.2 QUALIFICATION TESTS

9.2.1 Functional Test Requirements

Functional tests are performed to validate the operation of the hardware to the requirements of Section 3.1.2. Functionals make up the core of certain tests (like a PDA) and can be performed before and after environmental testing. The functional done prior to testing establish the functional state (or baseline) of the hardware, while the functional done after testing evaluates its ability to withstand the test levels .

An abbreviated functional will be used to test the functional state of the hardware during some environmental testing (i.e., thermal, vibration, bench handling, etc.). The intended use of an abbreviated functional is to verify nominal hardware functions between test stages.

9.2.2 Random Vibration Test

Random vibration testing is required for all HRF rack mounted hardware. Random vibration testing is not required for hardware packed in vibration damping materials, such as foam, or for hardware launched in soft stowage containers. Each HRF instrument or EUE subjected to vibration testing shall be functionally tested before and after vibration testing. It is also preferred that the hardware be operating and functionally tested during vibration testing. An assessment of the impact of operating the hardware during vibration testing shall be conducted, and recommendations shall be presented. The pass-fail criteria for the functional test and the definition of the functional test will be equipment unique and shall be defined in the test plan and test procedure for each element.

It is recommended that the hardware be hard mounted to the vibration test fixture in order to achieve a one-to-one transfer of the vibration levels shown in the following paragraphs. If the individual hardware flight mounting configuration is expected to result in amplification of flight vibration levels above the test levels defined in the following paragraphs, a test program should be developed that verifies the survivability of the hardware.

Requirements for qualification vibration testing are defined in SSP 52005.
Requirements for acceptance vibration testing are defined in SP-T-0023.
(PRD 5.4.1.1.3)

9.2.2.1 Qualification Random Vibration Test

QVT certifies the design for a number of launch cycles determined by the duration of the vibration test in each axis. QVT shall be conducted on dedicated qualification test hardware only. Spectral density and frequency of QVT vibration levels shall be equivalent to expected flight levels. The duration of the QVT shall be four times the expected life time exposure to flight vibration, but not less than 60 sec per axis.

Hardware may be certified for additional launch cycles by increasing vibration duration by 30 seconds in each axis for each additional launch cycle required. HRF requires a minimum duration of 120 seconds in each axis. The flight level vibrations for QVT are shown below. (PRD 5.4.1.1.3.1)

Frequency	Level
20 Hz	0.005 g^2/Hz
20-70 Hz	+5 dB/octave
70-350 Hz	0.004 g^2/Hz
350-2000 Hz	-3.9 dB/octave
2000 Hz	0.002 g^2/Hz
Composite	4.4 g RMS

9.2.2.2 Qualification for Acceptance Random Vibration Test

Not Applicable.

9.2.3 Thermal Cycle Test

HRF payloads undergoing thermal cycle testing shall be functionally tested at each stable temperature and during transitions. The pass-fail criteria for the functional test and the definition of the functional test will be equipment unique and shall be defined in the test plan and test procedure. Functional tests shall be conducted on end items prior to, during, and after environmental exposure. (PRD 5.4.1.1.6)

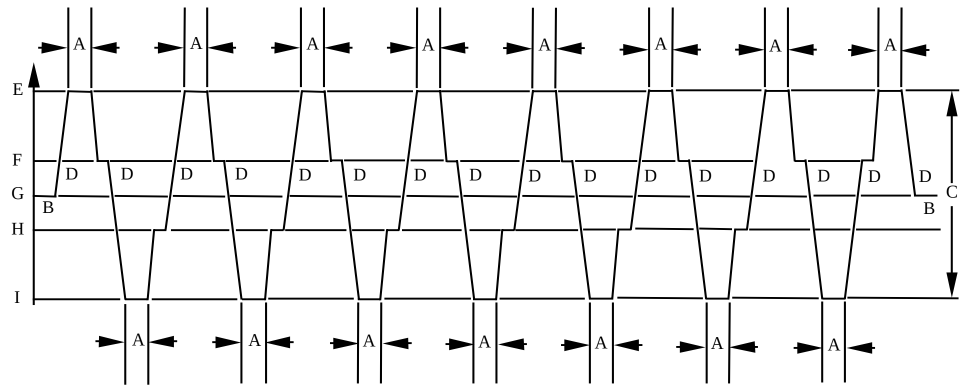
9.2.3.1 Acceptance Thermal Cycle Test

Qualification thermal cycle test shall be conducted on qualification units only. The test shall be conducted over a temperature range of 61.1 °C (110 °F) centered around the normal operating temperature, 75 °F. The qualification thermal test shall consist of seven and one-half cycles. One cycle is defined as the starting time from normal operating temperature increasing to the maximum high temperature, decreasing to the maximum low temperature, and then returning to the normal operating temperature. The hardware will be functionally tested during transitions, at the highest and lowest temperature extremes, consistent with the defined operating temperature range. If the hardware operating temperature range is less than the temperature extremes of the test, the hardware shall not be operated or tested until the test temperature is within the design operating temperature of the hardware. The specific profile shall be defined in the individual test plans.

Figure 9.2.3.1-1 shows the test profile for qualification thermal cycle test. The complete test is one and one-half cycles with one hour soaks at each extreme. (PRD 5.4.1.1.6.1)

9.2.4 Shock Test

Not Applicable. Refrigerated centrifuge will be transported in proper packaging to protect from excessive shocks. (PRD 5.4.1.1.4)



NOTES:

1. A = Time to stabilize equipment temperature plus 1 hour.
2. B = Functional tests to be performed as shown.
3. C = Control temperature range between high and low acceptance test.
4. D = Simplified functional test (optional). Rate of temperature change during transition shall not be less than 0.55 ^{o}C (1 ^{o}F)/min or greater than 2.22 ^{o}C (4 ^{o}F)/min.
5. E = Median operational temperature plus 30.56 ^{o}C (55 ^{o}F).
6. F = Maximum operational temperature.
7. G = Median operational temperature.
8. H = Minimum operational temperature.
9. I = Median operational temperature minus 30.56 ^{o}C (55 ^{o}F).

Figure 9.2.3.1-1 Qualification Thermal Cycling

9.2.5 Bench Handling Test

The bench handling test shall be conducted in accordance with MIL-STD-810, Section 516.4, I-3.6, Procedure 6 with the following modifications:

Test conditions of 26 drops will be altered to two (2) drops.

Surfaces, corners, edges shall be identified in the test procedure. (PRD 5.4.1.1.5)

9.2.6 Sinusoidal Resonance Survey

HRF rack mounted instruments shall be subjected to a sinusoidal resonance survey to determine the fundamental resonance frequencies of the test article. The survey shall be conducted at a sweep rate of one octave per minute in each of three orthogonal axes from 5 to 200 Hz, one sweep up and down, with an input not to exceed 0.25 g zero to peak. The equipment under test shall have an accelerometer mounted at an accessible hard point on the test item near or on the center of gravity of the test article. The output of this response accelerometer shall be monitored to not allow the hardware to experience more than 0.5 g peak. The input acceleration level shall be monitored by an accelerometer mounted as close as possible to the test fixture/hardware interface. (PRD 5.4.1.1.2)

9.2.7 Acoustic Noise Surveys and Tests

The LS-71011, “Acoustic Noise Control and Analysis Plan for Human Research Facility Payloads and Racks,” shall address verification methodology for ensuring that each payload and the integrated rack meet the acoustic requirements as defined in paragraph 5.1.3.3. (PRD 5.4.1.1.7)

9.2.8 Flammability Tests

Payload materials shall be nonflammable or self-extinguishing per the test criteria of NASA-STD-6001, Test 1, Flammability, Odor, Offgassing, and Compatibility Requirements and Test Procedures for Materials in Environments that Support Combustion. The material shall be evaluated in the worst-case use environment at the worst-case use configuration. When the use of nonflammable material is not possible, a Material Usage Agreement or equivalent shall be submitted to the cognizant NASA center for disposition. If test data does not exist for a material, the experimenter may be asked to provide samples (NASA-STD-6001, Chapter 4) to a NASA certified test facility at Marshall Space Flight Center (MSFC) or White Sands Test Facility for flammability testing.

Materials transported or operated in the orbiter cabin or operated in the ISS air lock during Extravehicular Activity preparations shall be tested and evaluated for flammability in the worst-case use environment of 30-percent oxygen and 10.2 psia. Materials used in all other habitable areas shall be tested and evaluated in the worst-case use environment of 24.1 percent oxygen and 15.2 psia. (PRD 5.4.1.1.8)

9.2.9 Off Gassing (Toxicity)

All flight hardware located in habitable areas shall be subjected to test and shall meet the toxicity off gassing acceptance requirements of NASA-STD-6001, Test 7. (PRD 5.4.1.1.9)

10.0 CONFIGURATION AND CHANGE CONTROL

Configuration of this equipment will be established through appropriate design reviews. A baseline configuration for flight hardware will be released via JSC drawings in accordance with JSCM-8500, “JSCM Engineering Drawing Practices.” These released engineering drawings shall define the configuration sufficient to allow storage accommodations definition, end item identification, end item modification, and end item fabrication/assembly as appropriate. The end items of this document shall be configured in accordance with the configuration on the top assembly drawings as listed in Section 2.4 of this document. Fabrication and assembly shall comply with approved drawings and Drawing Change Notices (DCN).

Any changes to this Hardware Requirements Document or the released drawings will be approved via a CR to the CCB, as appropriate, via LS-71005, “Configuration Management Plan for the Human Research Facility.” Not all drawing changes have to go to the CCB, but those that affect the fit, form, and/or function of the hardware shall be approved at the CCB.

11.0 SAFETY, RELIABILITY, MAINTAINABILITY, AND QUALITY ASSURANCE

11.1 SAFETY

The processes, responsibilities, and schedules for the development of flight safety data packages are specified in LS-71002, "System Safety Program Plan for the Human Research Facility." (PRD 7.1)

11.1.1 Payload Safety Requirements

HRF payloads shall be designed to meet the requirements of NSTS 1700.7B and NSTS 1700.7B ISS Addendum, KHB 1700.7, and NSTS/ISS 18798. (PRD 7.1.1)

11.1.2 Safety Documentation

Safety documentation shall be prepared in accordance with the data submittal requirements in NSTS/ISS 13830. (PRD 7.1.2)

11.2 RELIABILITY AND MAINTAINABILITY

Reliability and maintainability requirements for HRF integrated rack hardware shall be as defined in LS-71026, "Human Research Facility (HRF) Reliability Plan." (PRD 7.2)

11.2.1 Useful Life

HRF Class C flight hardware will be designed for a 10 year utilization. HRF Class D flight hardware will be designed for a utilization life cycle in accordance with science requirements and budgetary constraints. (PRD 7.2.1)

11.3 QUALITY ASSURANCE

11.3.1 Human Research Facility Quality Plan

Quality Assurance for the HRF Program shall be implemented in accordance with the LS-71030, "Quality Assurance Plan for the Human Research Facility." (PRD 7.3.1)

11.3.2 Non-Conformance Reporting

1. For flight hardware procured under a NASA contract or subcontract at a site other than JSC, non-conformance reporting requirements shall be specified in the SOW Data Requirement List, and DRDs shall be used to identify the submittal and data requirements. (PRD 7.3.2)
2. For flight hardware developed at JSC, non-conformance reporting shall be in accordance with JPD 5335.1 and the applicable technical division plan and shall be addressed in the end item acceptance and certification plan.
3. Non-conformances, which meet the Level 1 Problem Reporting and Corrective Action criteria for payloads as defined in SSP 30223, shall be reported in accordance with SSP 30223.
4. Software non-conformance reporting shall be in accordance with LS-71020-1, "Software Development Plan for the Human Research Facility."

TABLE 11-1. SAFETY AND MISSION ASSURANCE DOCUMENTATION LIST

METHODS
A Applicable
N/A Non-Applicable

Requirement	Acceptance		Qualification		Verification Document	Open (O) Closed (X)	Comments
	Meth.	Procedure	Meth.	Procedure			
Failure Mode and Effects Analysis			A		Fill-in your FMEA/CIL document # here.	O	Shall be supplied at PDR.
Critical Items List (CIL)			A		Fill-in your FMEA/CIL document # here.	O	Shall be supplied at Critical Design Review.
Limited Life Items List			A		See Comments.	O	As required.
Certification Report			A		See Comments.	O	Safety and Mission Assurance Certification Approval Request Form and certification package shall constitute the certification report.
Stress Analysis Report			A		If applicable and available, place document # here.	O	If needed for your hardware, supply due date and what report it will focus on.
Fracture Control Analysis			A		If applicable and available, place document # here.	O	If needed for your hardware, supply due date and what report it will focus on.
Thermal Analysis			A		If applicable and available, place document # here.	O	If needed for your hardware, supply due date and what report it will focus on.
Payload Safety Data Package			A		Fill-in your Phase package(s) document number here.	O	The hardware described in this HRD shall be included in the four HRF phased safety data packages.
Safety Analysis Report			N/A		Not applicable for payloads	X	
Accident or Incident Report			N/A		See Comments.	X	DR system shall be used during the certification and acceptance program.
Failure Report			N/A		See Comments.		DR system shall be used during the certification and acceptance program.
Redundant Path Verification			A		Fill-in your FMEA/CIL document # here.	O	A part of the FMEA/CIL document.

TABLE 11-1. SAFETY AND MISSION ASSURANCE DOCUMENTATION LIST (Cont'd)

METHODS
A Applicable
N/A Non-Applicable

Requirement	Acceptance		Qualification		Verification Document	Open (O) Closed (X)	Comments
	Meth.	Procedure	Meth.	Procedure			
Separation of Redundant Path			A		Fill-in your FMEA/CIL document # here.	O	A part of the FMEA/CIL document.
Failure Propagation			A		Fill-in your FMEA/CIL document # here.	O	A part of the FMEA/CIL document.
Touch Temperature			A		If applicable and available, place document # here.	O	(If applicable, say the following, if not leave blank.) A part of the thermal analysis report document.
Test Plans							
Pre-Delivery Acceptance (PDA)			A		TPS or Drawing # TBD (unless known)		Performed for all flight and certification units.
Pre-Installation Acceptance (PIA)			A		TPS or Drawing # TBD (unless known)		Performed for all flight units.
Qualification Test(s)			A		Fill-in your document # here.		As required.

APPENDIX A
APPLICABILITY MATRIX

HRD Applicability Matrix

No.	Reference Document Item	Abbreviated Requirement Title	App.	HRD Para.	Comments
	SECTION 1				
1	FRD PARA. #	FUNCTIONAL REQUIREMENTS SECTION			
	2.2.1	The RC shall provide a system for separation of biological samples based on differing sample densities.	A	3.1.4.1	
	2.2.2	The RC shall provide timed centrifugation.	A	3.1.4.2	
	2.2.3	The RC shall provide selectable centrifugal force.	A	3.1.4.3	
	2.2.4	The RC shall accommodate varying sample sizes.	A	3.1.4.4	
	2.2.5	The RC shall provide programmable centrifugation protocols that may be overridden if necessary.	A	3.1.4.5	
	2.2.6	The RC shall provide a visual alert when centrifuge protocol has ended.	A	3.1.4.6	
	2.2.7	The RC shall provide emergency stop capability.	A	3.1.4.7	
	2.3.1	The RC shall provide selectable force over the range of 0 to 4000 g.	E	3.1.4.3A	Minimum range of 1000 to 5000 rpm
	2.3.2	The RC shall provide force that will be selectable in increments of 200g.	E	3.1.4.3B	Increments of 100 rpm, ≥10

A = Applicable
N/A = Not Applicable
E = Exception

HRD Applicability Matrix (Cont'd)

No.	Reference Document Item	Abbreviated Requirement Title	App.	HRD Para.	Comments
	2.3.3	The RC shall accommodate sample sizes of 5, 7, and 12 ml.	A	3.1.4.4A	From .5 to 50 ml
	2.3.4	The RC shall accommodate a minimum of 6 of the largest size vials at a time.	A	3.1.4.4B	6 of the 50 ml vials at a time
	2.3.5	The RC shall be capable of running from 1 to 30 minutes. It will be selectable in one minute increments. There will be a hold feature to allow for indefinite run times.	A	3.1.4.2	
	ARC/BRP-40006	BRP REQUIREMENTS			
	3.15a	The RC will provide continuous acceleration over the range of 0 to 4000 g.	E	3.1.4.3A	From 1000 to 4000g
	3.15b	The acceleration of the RC will be selectable in increments of 200 g ±5 g.	A	3.1.4.3B	
	3.15c	The RC will process samples sizes from 0.5 to 50 ml.	A	3.1.4.4A	
	3.15f	The RC will process up to 8 samples of the largest sample vial at a time.	E	3.1.4.4B	…up to six of the 50 ml vials at a time
	3.15i	The RC will be capable of running from 0 to 180 minutes. It will be selectable in 1 minute (min.) increments ± 0.5 min. in the 0-30 min. time period, in 10 min. increments ± 3 min. in the 30-60 min. time period, and 10 min. increments ± 5 min. in the 60-180 min. time period	E	3.1.4.2	From 1 to 30 minutes, increments of 1 minute and indefinite hold time
	3.15e	The temperature set points of the RC will be	A	3.1.4.9B	

HRD Applicability Matrix (Cont'd)

No.	Reference Document Item	Abbreviated Requirement Title	App.	HRD Para.	Comments
		selectable in 2 °C increments.			
	3.15j	The RC will be capable of manually controlled rotor acceleration and deceleration	A	3.1.4.10	…manually (or equivalent)
	3.15h	The RC will provide the capability to detect an unbalanced condition during centrifugation and automatically shut down.	A	3.1.4.8	
	3.15g	The RC will interface with the host command and data system	A	3.1.4.12	
	3.15k	The RC will be capable of decontamination according to NIH guidelines	E	4.9.3	The RC shall meet Visibly Clean-Sensitive (VC-S) cleanliness requirements as specified in SN-C-0005.
	3.15l	The temperature of the rotor chamber and the speed of the rotor in the refrigerated centrifuge will be recorded at one minute intervals and displayed continuously for the duration of operation.	A	3.1.4.11	Rotor chamber temperature and rotor speed shall be displayed continuously.
	3.15d	The RC will control the temperature of the samples to within ±2 °C of the set point in the range of 4 °C to ambient.	E	3.1.4.9a	The RC shall provide refrigeration to the rotor chamber to a minimum of 4 °C.

APPENDIX B

REFRIGERATE CENTRIFUGE VERIFICATION MATRIX

REFRIGERATE CENTRIFUGE VERIFICATION MATRIX

Certification Methods	Acceptance Procedures	Qualification Procedure
T : Test	PDA : Predelivery Acceptance	LT : Load Test
A : Analysis	PIA : Preinstallation Acceptance	SA : Stress Analysis
I : Inspection	ATT : Acceptance Thermal Test	QTT : Qualification Thermal Test
S : Similarity	AVT : Acceptance Vibration Test	F/C : Fit-Check
D : Demonstration	F/C : Fit-Check	QVT : Qualification Vibration Test
		QAVT : Qualification Acceptance Vib. Test
		FT : Functional Test
		QSWTP : Qualification Software Test Procedure

Para. No.	Requirement	Acceptance		Qualification		Verification	Open (O)	Comments
		Meth	Procedure	Meth	Procedure	Document	Closed (X)	
3.1.2	Deliverables							
3.1.3	Operations							
3.1.4	Performance Requirements							
3.1.4.1	Centrifugation	A	PDA	A	PDA		O	
3.1.4.2	Timed Centrifugation	D	PDA	D	PDA		O	
3.1.4.3	Programmable Force	D	PDA	D	PDA		O	
3.1.4.4	Sample Sizes	D	PDA	D	PDA		O	
3.1.4.5	Programmable Protocols	D	PDA	D	PDA		O	
3.1.4.6	Visual Alert	T	PDA	T	PDA		O	
3.1.4.7	Emergency Stop	D	PDA	D	PDA		O	
3.1.4.8	Unbalanced Conditions	T, D	PDA	T, D	PDA		O	
3.1.4.9	Refrigeration	T, D	PDA	T, D	PDA		O	
3.1.4.10	Controlled Acceleration/ Deceleration	D	PDA	D	PDA		O	
3.1.4.11	Displays	D	PDA	D	PDA		O	
3.1.5	Physical Requirements							
3.1.5.1	Maximum Dimensional Envelope	T	PDA	T	PDA		O	Dimensional Test
3.1.5.2	Dimensional Tolerances			A	PDA		O	Verify Drawings
3.1.5.3	HRF SIR Drawer Front Panel Permanent Protrusions			I	PDA		O	
3.1.5.3.1	HRF Rack Mounted Sir Drawer Center-of-Gravity Constraints	T	PDA	T	PDA		O	
3.1.5.4	Mass (Weight)	T	PDA	T	PDA		O	
3.1.6	Software Design Requirement							TBD
4.0	INTERFACE REQUIREMENTS							
4.1	Structural Mechanical Interface Requirements							
4.1.1	Safety Critical Structures			A			O	Stress Analysis Report
4.1.2	Dynamic Pressure			A			O	Stress Analysis Report

Para. No.	Requirement	Acceptance Meth	Acceptance Procedure	Qualification Meth	Qualification Procedure	Verification Document	Open (O) Closed (X)	Comments
4.1.3	First Model Frequency			A			O	Stress Analysis Report
4.1.4	SIR Drawer Structural/ Mechanical Interfaces			I	PDA		O	
4.1.5	Microgravity							
4.1.5.1	Quasi-Steady Requirements			T, A			O	Test operating frequencies, analysis for remaining frequencies
4.1.5.2	Vibratory Requirements			T, A			O	Test operating frequencies, analysis for remaining frequencies
4.1.5.3	Transient Requirements			T, A			O	Test operating frequencies, analysis for remaining frequencies
4.2	Electrical Interface Requirements							
4.2.1	HRF Rack Power Output Connectors							
4.2.1.1	SIR Drawer Power Connectors			A			O	Inspect and verify electrical schematics
4.2.2	Voltage Characteristics							
4.2.2.1	Steady-State Operating Voltage Envelope			T			O	
4.2.2.2	Transient Operating Voltage Envelope			A			O	
4.2.2.3	Ripple Voltage/Noise Characteristics			A			O	
4.2.3	Maximum Current Limit			T			O	
4.2.4	Reverse Current			T, I			O	
4.2.5	Reverse Energy			T, I			O	
4.2.6	Capacitive Loads			T			O	
4.2.7	Electrical Power Consumer Constraints							
4.2.7.1	Wire Derating			I			O	
4.2.7.2	Exclusive Power Feeds			I			O	
4.2.7.3	Loss of Power			A			O	
4.2.8	Electromagnetic Compatibility			A			O	
4.2.8.1	Electrical Grounding			T			O	Perform EMI test
4.2.8.2	Electrical Bonding			A			O	
4.2.8.3	Cable/Wire Design and Control Requirements			I			O	
4.2.8.4	Electromagnetic Interference			T			O	Perform EMI test
4.2.9	Electrostatic Discharge			I			O	
4.2.10	Alternating Current (AC) Magnetic Fields			T			O	

		Acceptance		Qualification		Verification	Open (O)	
Para. No.	Requirement	Meth	Procedure	Meth	Procedure	Document	Closed (X)	Comments
4.2.11	Direct Current (DC) Magnetic Fields			T			O	
4.2.12	Corona	N/A		N/A				
4.2.13	EMI Susceptibility for Safety-Critical Circuits			I, T			O	
4.2.14	Safety Requirements							
4.2.14.1	HRF RC Electrical Safety			A			O	Phase III Safety Data Package
4.2.14.1.1	Mating/Demating of Powered Connectors			A			O	Phase III Safety Data Package
4.2.14.1.2	Safety-Critical Circuits Redundancy			A			O	Phase III Safety Data Package
4.2.15	Power Switches/ Controls			I, D			O	
4.2.16	Ground Fault Circuit Interrupters (GFCI)/ Portable Equipment DC Sourcing Voltage	N/A		N/A				
4.2.17	Portable Equipment/ Power Cords						O	
4.3	Command and Data Handling Interface Requirements						O	
4.3.1	HRF Rack Data Connectors							
4.3.1.1	SIR Drawer Data Connectors			A,T	PDA			Review of drawings
4.3.2	TIA/EIA-422 Interface			A,T	PDA			
4.3.3	Software Requirements			A, T	PDA			
4.3.4	ISS C&DH Services			A, T	PDA			
4.4	Payload NTSC Video Interface Requirements	N/A		N/A				
4.5	Thermal Control Interface							
4.5.1	HRF Rack Heat Exchangers			I	PDA		O	
4.5.1.1	Heat Exchanger Interface Maximum Heat Load			A	PDA		O	
4.5.1.2	SIR Drawer Cooling Fans							
4.5.1.2.A	Fan Hardware			A	PDA		O	Review of drawings
4.5.1.2.B	Fan Location			I	PDA		O	Verify that the fan is located in the correct
4.5.1.2.C	Vibration Isolation			A	PDA		O	Review of drawings
4.5.1.2.D	Fan Mounting			D	PDA		O	
4.5.1.2.E	Fan Operating Voltage			T	PDA		O	
4.5.1.2.F	Fan Speed Controller			T, A	PDA		O	Thermal Analysis Report

Para. No.	Requirement	Acceptance Meth	Acceptance Procedure	Qualification Meth	Qualification Procedure	Verification Document	Open (O) Closed (X)	Comments
4.5.2	Front Surface Temperature			A			O	Thermal Analysis Report
4.5.3	Cabin Air Heat Leak	N/A		N/A				
4.5.4	Cabin Air Cooling	N/A		N/A				
4.6	Vacuum System Requirements	N/A		N/A				
4.7	Pressurized Gas Interface Requirements	N/A		N/A				
4.8	Payload Support Services Interfaces Requirements	N/A		N/A				
4.9	Materials and Parts Interface Requirements							
4.9.1	Materials and Parts Use and Selection			A				Material Cert. Report
4.9.2	Commercial Parts			A				Material Cert. Report
4.9.3	Cleanliness			A				Material Cert. Report
4.9.4	Fungus Resistant Material			A				Material Cert. Report
4.10	Fire Protection Interface Requirements							
4.10.1	Fire Prevention			A				Phase III Safety Data Package
4.10.2	Portable Fire Extinguisher	N/A		N/A				
4.10.3	Fire Suppression Access Port Accessibility	N/A		N/A				
4.10.4	Fire Suppressant Distribution							
5.0	GENERAL DESIGN REQUIREMENTS							
5	Human Factors							
5.1.1	Strength Requirements							
5.1.1.1	Operation and Control of Payload Equipment							
5.1.1.1.A	Grip Strength			D			O	HF2-HR-001-A
5.1.1.1.B	Preliminary Forces			D			O	HF2-HR-001-B
5.1.1.1.C	Torque			D			O	HF2-HR-001-C
5.1.1.2	Maintenance Operations			D				HF2-HR-001-B
5.1.2	Body Envelope and Reach Accessibility							
5.1.2.1	Adequate Clearance			D			O	HF2-HR-002
5.1.2.2	Accessibility							
5.1.2.2A	Visual Access			D			O	HF2-HR-003A
5.1.2.2B	IVA Clearance			D			O	HF2-HR-003B
5.1.2.3	Full Size Range Accommodation			I			O	Drawings HF2-HR-004

Para. No.	Requirement	Acceptance		Qualification		Verification	Open (O)	
		Meth	Procedure	Meth	Procedure	Document	Closed (X)	Comments
5.1.3	Habitability							
5.1.3.1	Housekeeping							
5.1.3.1.1	Closures or Covers			D, I			O	HF2-HR-005
5.1.3.1.2	Built-In-Control			D			O	HF2-HR-009
5.1.3.1.2A	Container			D, I			O	HF2-HR-006-A
5.1.3.1.2B	Capture			D			O	HF2-HR-006-B
5.1.3.1.3	One-Handed Operation			D			O	HF2-HR-009
5.1.4.1.4	Surface Materials			I			O	Drawings HF2-HR-126
5.1.3.2	Touch Temperature							
5.1.3.2.1	Continuous/Incidental Contact -High Temperature	N/A		N/A				Thermal Analysis Report
5.1.3.2.2	Continuous/Incidental Contact - Low Temperature			A, I				Thermal Analysis Report
5.1.3.3	Acoustic Requirements							
5.1.3.3.2	Intermittent Noise Limits			T			O	Evaluation Test HF2-HR-013-C-S
5.1.4	Lighting Design	N/A		N/A				
5.1.5	Color Schemes							
5.1.5.1	Rack Mounted Equipment	I	PDA	I	PDA		O	
5.1.5.2	Stowed/Deployable Equipment	N/A		N/A				Stowed Equipment is COTS
5.1.5.3	Colors for Soft Goods	N/A		N/A				
5.1.6	Structural/Mechanical Interfaces							
5.1.6.1	Hardware Protrusion Limits							
5.1.6.1.1	Permanent Protrusions	N/A		N/A				Rack Mounted
5.1.6.1.2	Intermittent Protrusions	N/A		N/A				Rack Mounted
5.1.6.1.3	Temporary Protrusions			I			O	HF2-HR-018-A-S
5.1.6.1.4	Clearance for Crew Restraints and Mobility Aids	N/A		N/A				
5.1.6.1.5	Fire Suppression Port Access	N/A		N/A				
5.1.6.2	Payload Hardware Mounting							
5.1.6.2.1	Equipment Mounting			D			O	HF2-HR-020
5.1.6.2.2	Drawers and Hinged Panels			I			O	HF2-HR-021-B
5.1.6.2.3	Alignment			I			O	HF2-HR-024
5.1.6.2.4	Slide-Out Stops			I			O	HF2-HR-026
5.1.6.2.5	Push-Pull Force			A			O	HF2-HR-027
5.1.6.2.6	Access			D			O	HF2-HR-028
5.1.6.2.6.1	Covers							
5.1.6.2.6.1.A	Sliding or Hinged Cap			I			O	HF2-HR-029-A

Para. No.	Requirement	Acceptance Meth	Acceptance Procedure	Qualification Meth	Qualification Procedure	Verification Document	Open (O) Closed (X)	Comments
5.1.6.2.6.1.B	Cover Plate			I			O	HF2-HR-029-B
5.1.6.2.6.2	Self-Supporting Covers			D, I			O	HF2-HR-030-C
5.1.6.2.6.3	Unique Tools			I			O	HF2-HR-127
5.1.6.3	Connectors							
5.1.6.3.1	One-Handed Operation			D			O	HF2-HR-031
5.1.6.3.2	Accessibility							
5.1.6.3.3	Ease of Disconnect			D, I			O	HF2-HR-034A
5.1.6.3.4	Indication of Pressure/ Flow	N/A		N/A				
5.1.6.3.5	Self Locking			I			O	HF2-HR-036
5.1.6.3.6	Connector Arrangement							
5.1.6.3.6.A	Space			I			O	HF2-HR-037-A-S
5.1.6.3.6.B	Clearance			I			O	HF2-HR-037-B
5.1.6.3.7	Arc Containment			I			O	HF2-HR-038-S
5.1.6.3.8	Connector Protection			I			O	HF2-HR-039
5.1.6.3.9	Connector Shape			I			O	HF2-HR-040
5.1.6.3.10	Fluid and Gas Line Connectors	N/A		N/A				
5.1.6.3.11	Alignment Marks or Guide Pins			I, D			O	HF2-HR-042
5.1.6.3.12	Coding							
A				I			O	HF2-HR-043-A
B				I, D			O	HF2-HR-043-B
5.1.6.3.13	Pin Identification			I			O	HF2-HR-044
5.1.6.3.14	Orientation	N/A		N/A				
5.1.6.3.15	Hose/Cable Restraints	N/A		N/A				No cables or hoses associated with this hardware
5.1.6.4	Fasteners							
5.1.6.4.1	Non-Threaded Fasteners Status Indication			I				HF2-HR-047
5.1.6.4.2	Mounting Bolt/Fastener Spacing			I			O	HF2-HR-048
5.1.6.4.3	Multiple Fasteners			I			O	HFR-HR-050
5.1.6.4.4	Captive Fasteners			I			O	HF2-HR-051
5.1.6.4.5	Quick Release Fasteners							
A	1 Turn			I			O	HF2-HR-052-A
B	Positive Locking Open			I, D			O	HF2-HR-052-B
5.1.6.4.6	Threaded Fasteners			I			O	HF2-HR-053
5.1.6.4.7	Over Center Latches							
A	Non-self latching			I, D			O	HF2-HR-054-A
B	Latch Lock			I, D			O	HF2-HR-054-B
C	Latch Handles			I, D			O	HF2-HR-054-C
5.1.6.4.8	Winghead Fasteners			I			O	HF2-HR-055
5.1.6.4.9	Fastener Head Type							
A	Hex			I			O	HF2-HR-057-A

Para. No.	Requirement	Acceptance Meth	Acceptance Procedure	Qualification Meth	Qualification Procedure	Verification Document	Open (O) Closed (X)	Comments
B	Smooth Surface			I			O	HF2-HR-057-B
C	Slotted			I			O	HF2-HR-057-C
5.1.6.4.10	One-Handed Actuation			D			O	HF2-HR-058
5.1.6.4.11	Accessibility			I			O	HF2-HR-059
5.1.6.4.12	Access Holes			I			O	HF2-HR-060
5.1.7	Controls and Displays							
5.1.7.1	Controls Spacing Design Requirements			I			O	HF2-HR-061
5.1.7.2	Accidental Actuation							
5.1.7.2.1	Protective Methods			I, D			O	Verify that one of the methods is in place (5.1.7.2.1A-D
5.1.7.2.2	Noninterference			I, D			O	HF2-HR-063
5.1.7.2.3	Dead-Man Controls							
5.1.7.2.4	Barrier Guards			I			O	HF2-HR-065
5.1.7.2.5	Recessed Switch Protection			I			O	HF2-HR-066
5.1.7.2.6	Position Indication			I, D			O	HF2-HR-068
5.1.7.2.7	Hidden Controls			I			O	HF2-HR-069
5.1.7.2.9	Hand Controllers			I			O	HF2-HR-070
5.1.7.3	Valve Controls	N/A		N/A				
5.1.7.4.1	Restraints and Mobility Aids	N/A		N/A				
5.1.8	Identification Labeling			I			O	HF2-HR-123
5.1.9	Crew Safety							
5.1.9.1	Electrical Hazards							
5.1.9.1-A				A			O	HF2-HR-124-A-S
5.1.9.1-B				A			O	HF2-HR-124-B-S
5.1.9.1-C				A			O	HF2-HR-124-C-S
5.1.9.1-D	Dependant Controls			A			O	HF2-HR-124-D-S
5.1.9.1-E	Independat Controls			A			O	HF2-HR-124-E-S
5.1.9.1.1	Mismatched			I, D			O	HF2-HR-102-S
5.1.9.1.2	Overload Protection							
5.1.9.1.2.1	Device Accessibility			I			O	HF2-HR-105-S
5.1.9.1.2.2	Extractor - Type Fuse Holder	N/A		N/A				
5.1.9.1.2.3	Overload Protection Location			I			O	HF2-HR-107-S
5.1.9.1.2.4	Overload Protection Identification			I			O	HF2-HR-108-S
5.1.9.1.2.5	Automatic Restart Protection			D			O	HF2-HR-109-S
5.1.9.2	Sharp Edges and Corners Protection	I	PDA	I	PDA		O	Quality Inspection of hdw.
5.1.9.3	Holes			I			O	HF2-HR-111-S
5.1.9.4	Latches			I			O	HF2-HR-112-A
5.1.9.5	Screws and Bolts			I			O	HF2-HR-113-S
5.1.9.6	Securing Pins			I			O	HF2-HR-114-S

Para. No.	Requirement	Acceptance		Qualification		Verification	Open (O)	Comments
		Meth	Procedure	Meth	Procedure	Document	Closed (X)	
5.1.9.7	Levers, Cranks, Hooks, and Controls	N/A		N/A				
5.1.9.8	Burrs	I	PDA	I	PDA		O	Quality Inspection of hdw. HF2-HR-116-S
5.1.9.9	Locking Wires	N/A		N/A				
5.1.9.10	Audio Devices (Displays)	N/A		N/A				
5.1.9.11	Egress			A			O	1230 Approval at Phase III Safety Review
5.1.10	Payload In-Flight Maintenance			I			O	HF2-HR-121-S
5.2	Construction Requirements							
5.2.1	Materials and Processes							
5.2.1.1	General Materials, Processes, and Parts Interface			A			O	Material Cert
5.2.1.2	Fracture/Fatigue			A			O	Material Cert
5.2.2	Screw Threads							
5.2.3	Fasteners							
5.2.4	Locking Devices							
5.2.4.1	Thread Locking Adhesive			A			O	Material Cert
5.2.4.2	Lock Wire	N/A		N/A				
5.3	Workmanship	T	AVT	T	AVT		O	
5.4	Interchangeability and Replaceability							
5.4.1	Maintainability On-Orbit							
5.4.2	Maintainability Ground							
5.5	Useful Life			A			O	LLIL
5.5.1	Operational Life (Cycles)			A			O	LLIL
5.5.2	Shelf Life			A			O	LLIL
5.5.3	Limited Life			A			O	LLIL
5.6	Electrical , Electronic, and Electromagnetic (EEE) Parts Requirements							
5.6.1	General Requirements			A				Material Cert
5.6.2	Part Selection			A				Material Cert
5.6.3	COTS/Modified COTS	T		T				72 and 96 hour burn-ins
6.1.1	Atmosphere Requriements							
6.1.1.1	Pressure			A			O	Stress Analysis
6.1.1.2	Temperature	T	ATT	T	QTT			
6.1.1.3	Humidity			A			O	
6.1.2	Instrument Use of cabin Atmospehre							

Para. No.	Requirement	Acceptance Meth	Acceptance Procedure	Qualification Meth	Qualification Procedure	Verification Document	Open (O) Closed (X)	Comments
6.1.2.1	Active Air Exchange	N/A		N/A				There is no active air exchange with the cabin
6.1.2.2	Oxygen Consumption	N/A		N/A				There is no oxygen exchange with the cabin.
6.1.2.3	Chemical Release			A				There is no planned chemical release
6.1.3	Ionizing Radiation Req							
6.1.3.1	Generated Ionizing Radiation							The system does not generate radiation
6.1.3.2	Ionizing Radiation Dose							
6.1.3.3	SEE Ionizing Radiation							
6.1.3.4	Additional Enviornemntal Concerns			A			O	
6.1.4	Ground Handeling							
6.1.4.1	Ground Handeling Load Factors							
6.1.4.1.1	Shock Criteria	N/A		N/A				
6.4.1.1.2	Bench Handeling			T			O	
6.2	Launch Loads							
6.2-A	MPLM ascent			A			O	Stress Analysis
6.2-B	Acceleration			T, A			O	Stress Analysis
6.3	On Orbit Loads							
6.3-A	Launch/landing			A			O	Stress Analysis
6.3-B	on-orbit			A			O	Stress Analysis
6.3-C	Crew Induced Loads			A			O	Stress Analysis
6.4	Random Vibration			T	AVT		O	

DISTRIBUTION LIST
FOR
LS-71004

NASA/JSC
SF2/D. Grounds

SF4/C. Haven

LOCKHEED MARTIN
S03/Science Payloads Library
S18/S. Ezell
S18/J. Hoge
S18/B. Rhone
S18/G. Salinas
S18/J. Hoge
S362/STI Center Bldg. 36 (8)